

HISTORICAL RADIOLOGICAL ASSESSMENT

PUGET SOUND NAVAL SHIPYARD

Volume I

NAVAL NUCLEAR PROPULSION PROGRAM

1963-1993

**RADIOLOGICAL CONTROL OFFICE
PUGET SOUND NAVAL SHIPYARD
BREMERTON, WASHINGTON 98314-5001**

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1.0 Executive Summary

1.1 Purpose

This Historical Radiological Assessment (HRA) has been prepared by Puget Sound Naval Shipyard (PSNS) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The purpose of this HRA is to catalog and present over 30 years of radiological environmental data within the framework of the CERCLA process and within the pathway scoring protocol of the revised Hazard Ranking System (HRS).

Volume I of this HRA addresses radioactivity associated with the Naval Nuclear Propulsion Program (NNPP). Volume II addresses general radioactive material (G-RAM), including all non-NNPP applications of radioactivity (both Radiological Affairs Support Program (RASP) material and any site-related medical applications). Different branches of the Navy are responsible for these categories of radioactivity, and different historical practices have applied.

1.2 Background

Puget Sound Naval Shipyard was first authorized to accomplish NNPP work in late 1963. During 1964 and early 1965 only limited component work (primarily training) was done. The first nuclear submarine availability began in July 1965.

Since 1965, the shipyard has conducted overhauls, refuelings, and shorter restricted availabilities on almost every type and class of nuclear-powered submarine and surface ship.

Beginning in 1963, before any radiological work was performed or a nuclear-powered ship was berthed at the shipyard, a baseline study of the radiological environment of the shipyard and surrounding waters was conducted. Radiological environmental monitoring has continued through the present. Results are forwarded to the NNPP headquarters which, since 1967, has published an annual report with distribution to other Federal Agencies, States, Congress, and the public.

Independent cross-checks of analytical results and independent surveys of the harbors have been an integral part of this Program since its inception. These independent verifications have been consistent with NNPP and shipyard results and conclusions.

1.3 Findings

No radioactivity associated with Naval nuclear propulsion plants has been detected in harbor water or marine life samples. Only trace amounts of radioactivity associated with the Naval Nuclear Propulsion Program have been detected in a few harbor sediment samples. Of all the radiological data collected by the shipyard and the Environmental Protection Agency, the only environmental radioactivity attributable to Naval nuclear propulsion plants is trace levels of cobalt-60 in sediment. This radioactivity is attributable to pre-1972 discharges of processed radioactive liquids, as discussed in annual reports issued by the NNPP. Even though NNPP release limits were well below federal requirements, the NNPP had eliminated these discharges by Program activities by about mid-1972. Since then, no radioactivity has been intentionally released by the shipyard. The effectiveness of NNPP controls in preventing radioactive releases resulting in significant impact on the public or the environment has been confirmed by the findings and conclusions of the Environmental Protection Agency (EPA) surveys performed in October 1974 and July-August 1987, reported in 1977 and 1989 and quoted in Section 6.1.1 of this HRA. Controls for prevention of release of radioactivity to the air, soil, and ground water pathways, and immediate control and remediation of inadvertent releases to these pathways, have been in place from the beginning of NNPP work.

1.4 Conclusions

This HRA concludes that: (a) the berthing of and work on nuclear-powered ships at PSNS has had no adverse effect on the human population or the environment of the region; (b) the trace levels of cobalt-60 found in sediment do not require remediation, due to the low levels detected and due to the environmental harm that would occur during removal of bottom material by extensive dredging; and (c) independent reviews by the Environmental Protection Agency are consistent with these conclusions. PSNS concludes that no additional characterization and no remedial actions are necessary as a result of NNPP activities at the shipyard.

2.0 Introduction

2.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established a process whereby past private sector disposal sites were scored for environmental contamination, and remedial action initiated where warranted. Federal facilities were not included within CERCLA; however, under Executive Order 12316 of August 20, 1981, the President directed the Department of Defense (DOD) to conduct similar evaluations of their installations.

By the mid-1980's, most DOD facilities had been evaluated. These Initial Assessment Studies were conducted for Naval shipyards and operating bases where nuclear-powered ships were maintained and berthed. The Puget Sound Naval Shipyard Initial Assessment Study (IAS), Reference 1, was completed in March 1990.

During 1986, DOD realigned its programs to be more consistent with those of the Environmental Protection Agency (EPA) in the private sector. Initial Assessment Studies paralleled the Preliminary Assessments and Site Inspections of CERCLA. Confirmation Studies paralleled the Remedial Investigation and Feasibility Studies of CERCLA.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 required that Federal agencies comply in the same manner and extent as private entities and allowed Federal activities to be placed on the National Priorities List (NPL). Executive Order 12580 of January 23, 1987 gave additional jurisdiction to the EPA for Federal facilities on the NPL.

SARA also directed the EPA to revise its Hazard Ranking System (HRS) used to score sites undergoing the CERCLA process. This was completed and the revised HRS was published in the Federal Register in December 1990.

A Preliminary Assessment (PA) for PSNS, Reference 2, was completed in June 1990, and the Site Inspection (SI), Reference 3, in April 1992. The EPA has scored PSNS under the revised Hazard Ranking System. Data collected during Site Inspection Studies, Reference 3, were used in this scoring. Due to past chemical disposal and control practices the score exceeded 28.5, and PSNS was placed on the NPL in 1994. The IAS, the SI, and the revised HRS scoring did not include consideration of any past releases of radioactivity associated with NNPP work since the emphasis during those efforts was on industrial and chemical pollutants.

2.2 Purpose

This Historical Radiological Assessment (HRA) was produced to provide a comprehensive review and assessment of the impact of radiological operations at PSNS. This assessment is organized in a format similar to the standard Preliminary Assessment (PA) protocol used by the EPA within the CERCLA process. This format was chosen as a vehicle that is in common use and is easily understood.

Environmental radiological data collected for PSNS is cataloged and presented within the pathway evaluation protocol of the PA. Additional environmental radiological data collected by the EPA and their independent conclusions are included in the relevant sections of this assessment.

Section 8 of this assessment addresses each pathway along with the salient data results contained in previous sections and evaluates estimates of radiological impact to the public and to the environment from PSNS operations.

This assessment is historical in that the regulatory and policy changes that have occurred during the evolution of the NNPP are included as an explanatory supplement to the analytical results.

2.3 Methods

2.3.1 Counting Terminology

"Gross gamma" spectrometry systems used for counting environmental samples are currently calibrated to respond to gamma energies between 0.1 MeV and 2.1 MeV, and thus detect a combined total of all radionuclides with gamma energies between 0.1 and 2.1 MeV. (The gross gamma energy range for counting systems used from 1966 through 1973 was between 0.1 and 2.0 MeV). Similarly, "cobalt-60 energy range" gamma spectrometry is used to identify total gamma radioactivity in the range of 1.1 to 1.4 MeV. Where activity in this range is above 1 pCi/g, detailed radionuclide analysis is performed to determine whether cobalt-60 is present or whether all the activity is due to other (natural or fallout-related) radionuclides. For some analyses (e.g., modern environmental monitoring sediment, water, and biota samples), detailed radionuclide analysis is performed regardless of measured gamma levels.

Spectrometry detectors, whether sodium iodide or germanium, have conversion efficiencies which vary as a function of the incident gamma energy. This means that in order to determine the amount of a given radionuclide in a sample, the efficiency of the detector for that specific radionuclide would have to be determined using a known source of that radionuclide.

Alternatively, a source containing known quantities of several radionuclides with gamma energies ranging from about 0.15 MeV to about 2.0 MeV can be used to construct an efficiency curve for the detector.

A simpler approach is to assign the efficiency for a particular radionuclide to all energies between the upper and lower limits of the region of interest. For the NNPP, cobalt-60 is the most predominant radionuclide and has the most restrictive concentration limit in air and water of all the radionuclides identified in Naval reactor plants. If all of the radionuclides with gammas occurring within a given band of energies are quantified by using the efficiency of the most limiting radionuclide, the resulting calculated quantity will conservatively overestimate the actual radioactivity for the radionuclide of concern.

Gross gamma, cobalt-60 equivalent is the quantity of all radioactivity in the gamma energy range of interest (0.1-2.1 MeV) calculated using the efficiency value of cobalt-60. Cobalt-60 energy range radioactivity is calculated using the cobalt-60 efficiency for all energies between 1.1 MeV and 1.4 MeV.

Natural background radionuclides generally have only one gamma per disintegration, of lower energy than cobalt-60's two gamma's (potassium-40 is an exception). Hence, actual background radioactivity is likely higher than measured and reported by this procedure. This is acceptable since background radioactivity is not of concern in these "gross gamma" and "cobalt-60 energy range" measurements. (This is also the basis for the term "cobalt-60 equivalent activity," since instruments are calibrated for pure cobalt-60 activity.)

When detailed radionuclide analyses are performed, germanium detectors are used. "Actual cobalt-60 radioactivity" or "specific cobalt-60" is the amount of cobalt-60 only, based on the counts in the 1.33 MeV photopeak and the efficiency of the detector at that photopeak using a known cobalt-60 source in a geometry equivalent to that of the sample.

2.3.2 The Investigatory Process

The pathways, targets, and potential release mechanisms described in this HRA were used to guide the process of selecting the information to be reviewed in preparing this assessment. During the course of the investigation, they were used to gauge the adequacy of the historical record of radiological work at PSNS.

Information descriptive of PSNS was in large measure taken from recent Navy Installation Restoration documents. Navy and PSNS correspondence and history files were reviewed to ensure all potential source terms of radioactivity were identified. Navy and PSNS historical records were reviewed to ensure that an accurate account is presented of past requirements and practices.

All available records related to release, monitoring, and waste disposal were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases of radioactivity to the environment were not immediately remediated. Records of areas formerly used for radiological work were reviewed to determine whether all such areas have been appropriately released from radiological controls in accordance with all applicable requirements. A more detailed discussion of the specific types of records reviewed, and the results of that review, are contained in Section 5.

2.3.3 Interviews

Interviews with about a dozen long-term and previous employees were conducted to examine whether the body of documented records is complete. These interviews consisted of face-to-face discussions and telephone conversations related to the employee's position, responsibilities, periods of employment, and involvement in selected elements applicable to the HRA. Employees were specifically questioned if any environmental releases had occurred that were not documented, whether any disposal of radioactive material had occurred on-site, and whether any radiological practices documented by historical records forming the basis of this HRA had changed. No cases of unreported environmental releases of radioactivity or unauthorized disposal of radioactive material were identified, nor were any past radiological practices reported to be different from those documented in this HRA.

2.3.4 Units

Units used throughout this report include: pCi/100 cm² (picocurie per 100 centimeters squared), pCi/g (picocurie per gram), kcpm (thousand counts per minute), µCi/ml (microcurie per milliliter), Ci/yr (Curie per year), mrem/hr (millirem per hour), and µR/hr (microrentgen per hour). A further explanation of a particular unit can be found in the glossary.

3.0 Site Description

Except for Section 3.2.2, Navy Ownership History, this Section is based on Section 2.0 of the Site Inspection Report, Reference 3.

3.1 Site Name and Location

Puget Sound Naval Shipyard
Bremerton, Washington 98314-5001
CERCLIS ID #: WA2170023418

Puget Sound Naval Shipyard (PSNS) is in Kitsap County in the city of Bremerton, Washington. It is in the southeastern portion of the Kitsap Peninsula on the north side of Sinclair Inlet in Puget Sound. The city of Port Orchard is located to the south across Sinclair Inlet. The town of Gorst is southwest at the head of the Inlet.

The shipyard is located at latitude 47° 33' N and longitude 122° 38' W. Figure 3-1 is a copy of two spliced 7.5 minute quadrangle maps, for the Bremerton East and Bremerton West quadrangles. The shipyard is clearly designated. Circles of 1/4, 1/2, 1, 2, 3, and 4 mile radii are shown. Figure 3-2 is a vicinity map of the shipyard. Figure 3-3 (a)-(c) are historical photographs of PSNS taken in 1962, 1974, and 1993. Figure 3-4 is a drawing of the shipyard identifying building numbers, pier and berth designations, etc. The shipyard boundary is shown by a dark solid line. The boundary of the Controlled Industrial Area (CIA) is shown by a dashed line.

Several tenant commands are co-located on shipyard property. Hence, this site is also referred to as the Bremerton Naval Complex (BNC) in some documents.

The "Puget Sound Naval Shipyard, Bremerton Annex" identified on Figure 3-1, west of Ostrich Bay, is actually Jackson Park Navy Housing. It is also the location of Naval Hospital Bremerton. It has no NNPP radiological history or shipyard related industrial activity, and is not further discussed in this HRA.

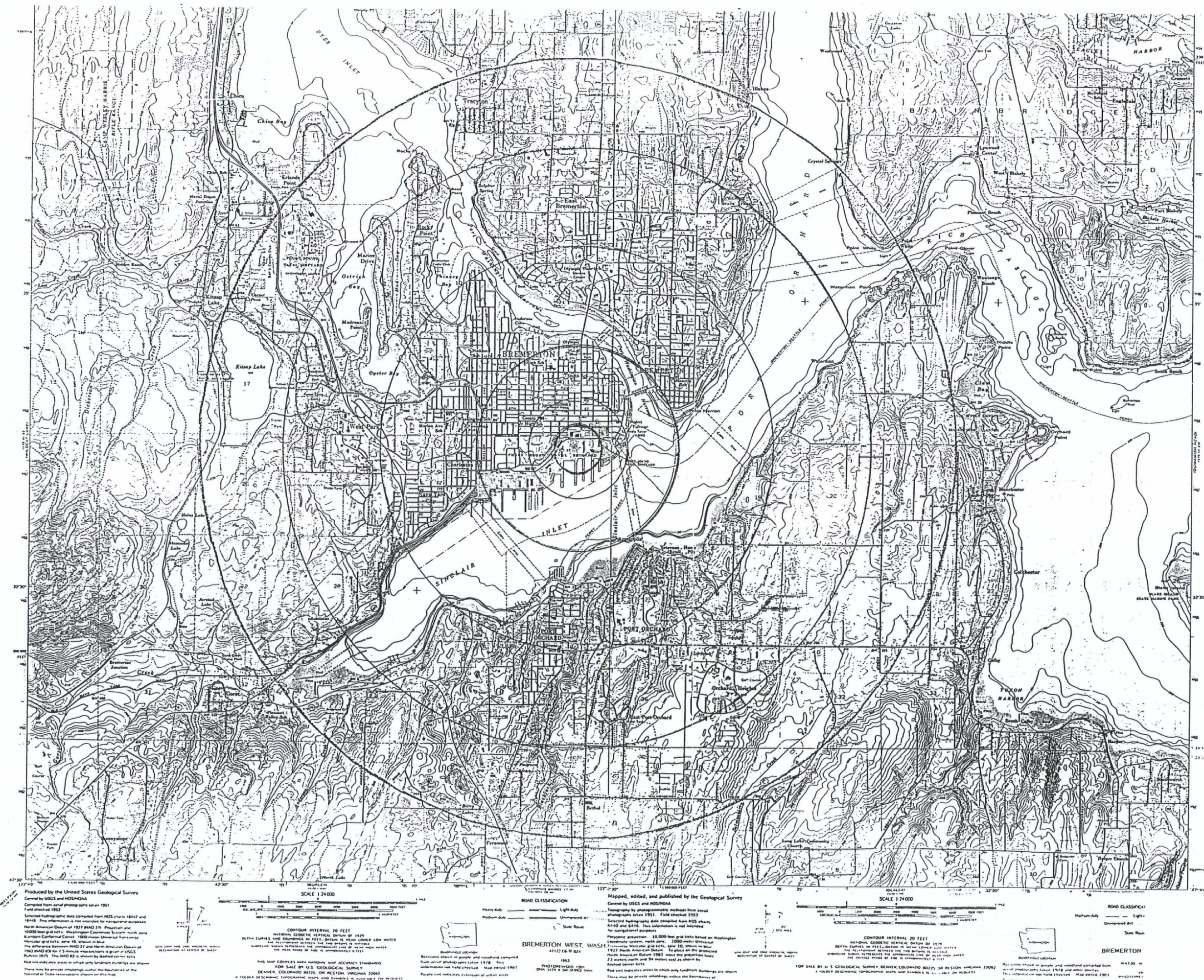


Figure 3-1
7.5 Minute Quadrangle Maps
Radii of circles are
 $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 3, and 4 miles

Figure 3-3 (a)

Puget Sound Naval Shipyard, 1962 Looking northwest. Pier 6 with the hammerhead crane in the foreground.



Figure 3-3 (b)

Puget Sound Naval Shipyard, Bremerton, and Vicinity, 1974 Looking northwest. Olympic mountains in the background.

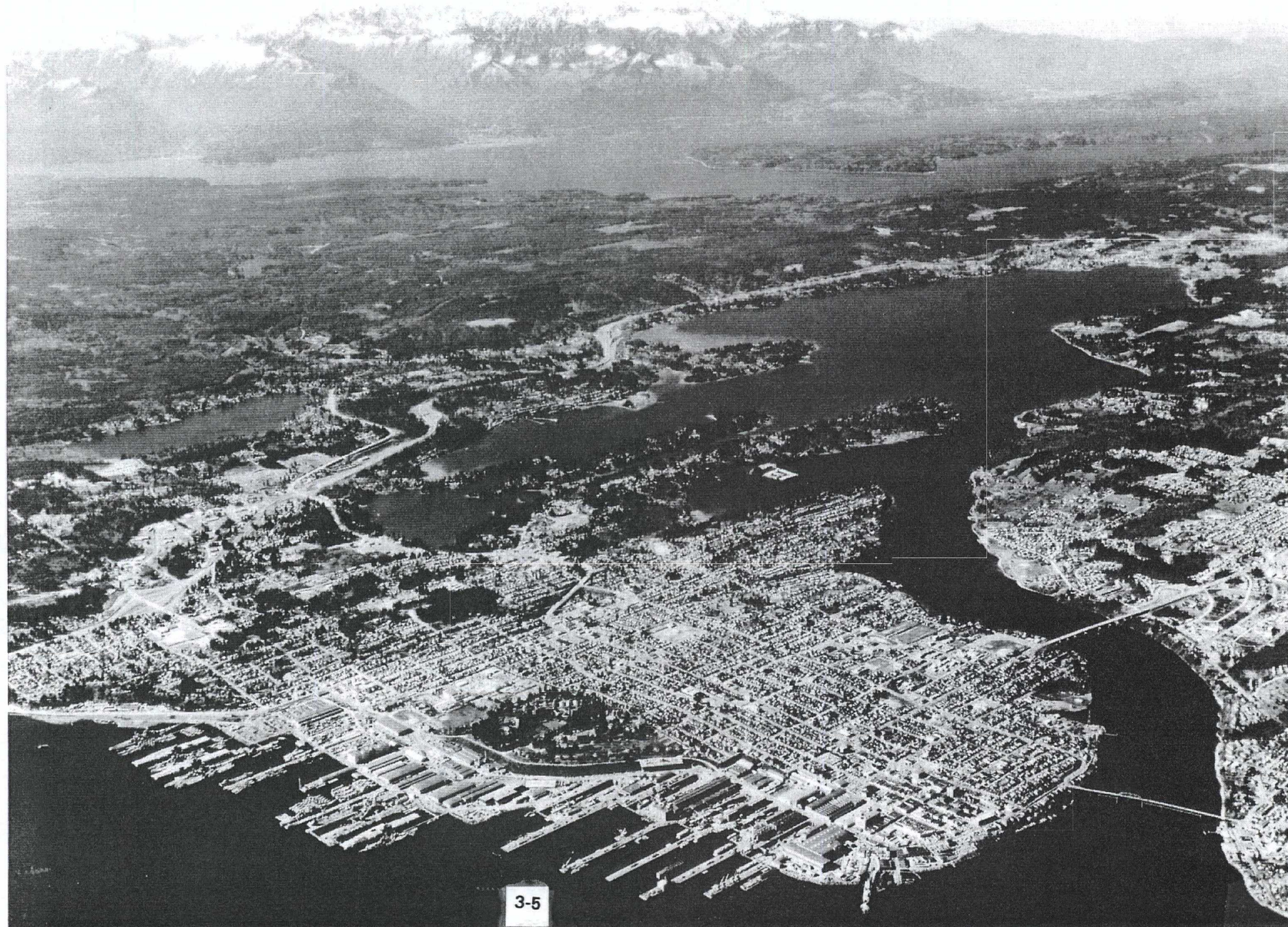
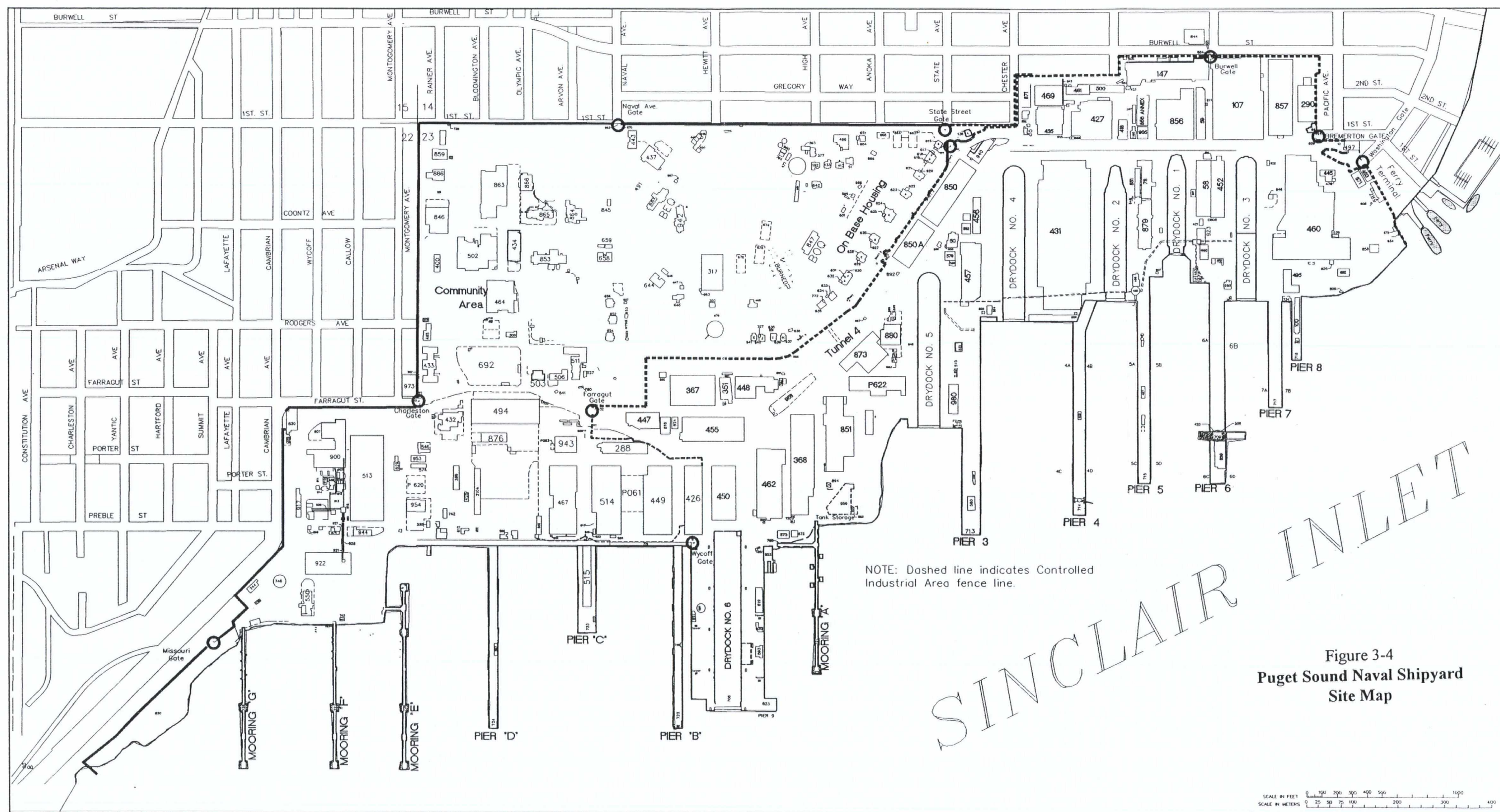


Figure 3-3 (c)
Puget Sound Naval Shipyard, 1993 Looking west.





3.2 Site History

3.2.1 Type of Site

PSNS is a public shipyard dedicated to the repair, overhaul, modernization, and disposal of Navy warships and auxiliaries. PSNS now consists of more than 300 acres with almost two miles of shoreline. PSNS contains about 330 industrial, administrative, and personnel support buildings and structures. About 100 buildings are major facilities. PSNS has six deep-water piers; six drydocks, ranging in length from 638 feet to 1,151 feet; and numerous moorings.

3.2.2 Navy Ownership History (Reference 4)

3.2.2.1 1891 - 1913

One hundred and ninety acres were purchased by the U.S. Government and designated as Puget Sound Naval Station in 1891. In the course of the next half a century it expanded to over 300 acres.

Construction of Puget Sound Naval Shipyard's first drydock, now known as Drydock 1, was completed in April 1896. Originally constructed of timber, the dock was reconstructed with concrete in 1931.

In 1900 and 1901, successive appropriations of \$300,000 and \$500,000 enabled the construction of general office buildings, a dispensary, officer quarters, the grading of the land, and the installation of electric lights. In 1902, the Station was raised in rank, and its name officially changed to Navy Yard Puget Sound. In 1906, Congress authorized a second drydock big enough to handle large warships. Drydock 2, made of granite and concrete, was completed in March 1913.

3.2.2.2 1914 - 1938

At the outbreak of World War I, Navy Yard Puget Sound was well established as a major repair base. Expansion of shops and facilities had been gradual, in keeping with the demands of the Navy's west coast ship overhaul and repair jobs of that period. With the European war imminent, the Navy Department began rapidly increasing and improving its shipyard installations. Authorities evidently realized that Puget Sound was not strategically located to serve as an important repair base for a war in the North Atlantic. Consequently, as plans formulated, the Yard's function changed from overhaul to new construction. In order to accomplish this objective, added resources in both berthing and building were required at once.

The basic facilities development plan presented in 1916 was instrumental in the building of one of the Navy's most efficient shipyards. \$52,000 was authorized in March 1917 to construct a shallow drydock for new ship construction. Work on the shipbuilding drydock was begun in August 1917, and was completed in January 1919. The existence of Drydock 3 allowed Puget Sound to underbid other shipyards for new construction jobs.

The World War I era led to many other important additions at Puget Sound. Shipbuilding ways were constructed, a reinforced concrete general storehouse was begun, and a hospital was built in 1917. The yard's work force rose to 6,500 in 1917.

Pier 5, identical in size to the existing Pier 4, was constructed in the early 1920's. The need for additional fitting out facilities for a battleship fleet based at Puget Sound was realized and in 1926 construction of Pier 6, the largest pier (1,200 feet long by 100 feet wide) was accomplished.

At the beginning of 1932, the yard's work force was about 2,800.

By 1933, the need for permanent equipment capable of lifting battleship guns, turrets, and barrettes had become imperative, and the huge revolving hammerhead crane was erected near the end of Pier 6. It could handle 250 gross tons at a 115 foot radius and could reach equally well to both sides of the pier. One extensive drydock alteration occurred in 1930 when Drydock 2 was increased to 867 feet in length so it could accommodate the large new aircraft carriers.

The yard's development on an increased scale began immediately following the 1932 change in the Federal government, and institution of the National Industrial Recovery Act and Work Projects Administration (WPA). A one-and-a-half-million-dollar Machine Shop was begun in 1933 and completed in 1935. Its floor space totaled five acres and it was described as "the finest of its kind in the nation."

Other yard improvements took place during this period, including construction of buildings, paving, and improvement of railroad tracks, roads, and distribution systems. In 1938, a new Industrial Dispensary and a three-story Naval Barracks Building were erected.

3.2.2.3 1939 - 1959

In response to the start of World War II in Europe in 1939, the yard's work force was increased to 6,000. By December 1941, the work force was 17,000. By war's end it had reached 32,000.

Drydock 4 was completed in 1940. 1,000 feet long, 132 feet wide, and 45 feet deep, it could accommodate any ship of the Fleet at that time.

Wartime activity demanded expansion of nearly all peacetime facilities. Major acquisitions of this period were Drydock 5, a Shipfitter Shop, a seven-story Supply Building, a Heavy Forge Shop, a Storehouse, an Electrical Shop, several shop buildings, a Supply Pier, and Piers 3 and 7. High priority new construction assignments demanded the construction of building ways, associated shops, and assembly slabs. Construction of Naval Ammunition Depot, Bangor, provided the Navy Yard its first direct rail link with major railroads in 1945.

"VJ" Day, August 14, 1945, marked the start of a transition to peacetime operations. By the end of 1946, the work force had declined to less than 9,000, primarily engaged in ship overhauls and inactivations.

On November 30, 1945, the Navy Yard was redesignated as a Naval Shipyard. The Naval Hospital, Marine Barracks, Naval Barracks, and Inactive Fleet Berthing areas were established as separate tenant commands under U. S. Naval Base, Bremerton. The Bremerton Group Reserve Fleet was subsequently established and in 1947, mooring facilities consisting of four moorings 800 feet long (moorings "A", "E", "F", and "G"), and two mooring piers 1,200 feet long (piers "B" and "D"), were completed in the west end of the shipyard to berth inactivated ships. All tenant commands have been co-located on shipyard property.

Between World War II and the Korean War, no new ship construction work was accomplished by the shipyard. The onset of the Korean War in 1950 saw the work force increase from 7,800 to 15,300 by mid-1952. By August 1950, the shipyard had 16 ship activations underway, in addition to overhauls and aircraft carrier conversions to handle jet aircraft.

The end of the Korean War in 1953 started another post war decline in the work force as ships were again inactivated and carrier conversions returned to peacetime schedules. Carr Inlet Acoustic Range was established in 1953. In 1956, a notch was built at the head of Drydock 5 and new gantry crane tracks were installed around the dock, to clear the overhang from large aircraft carrier flight decks.

3.2.2.4 1960 - 1993

Drydock 6, one of the largest drydocks in the world, was completed in April 1962. Designed to hold the new "super carriers," it is 180 feet wide, 1,180 feet long, and 61 feet deep.

In 1961, Puget Sound Naval Shipyard was selected to participate in the Navy's nuclear power program. PSNS became both a nuclear submarine shipyard and one of the few Naval shipyards with nuclear-powered surface ship capabilities. By 1962, a Nuclear Power Division had been staffed, nuclear power facility construction was under way, personnel were being trained, and conventional submarines were being overhauled to acquaint the shipyard with issues specific to submarines.

The shipyard's radiological environmental monitoring program started in 1963. The first nuclear ship to visit the shipyard, the submarine USS BARB (SSN 596), arrived in November 1963 and moored at Pier 6. The shipyard began limited work on a nuclear-powered ship, the submarine USS SCULPIN (SSN 590), in 1965, and started their first reactor plant overhaul in 1967 on USS SNOOK (SSN 592). The first nuclear-powered surface ship work was begun on USS ENTERPRISE (CVN 65) in 1968.

Since 1968 the shipyard has overhauled and refueled numerous nuclear-powered submarines and surface ships. In 1980 the first inactivations of nuclear-powered submarines were performed on USS THEODORE ROOSEVELT (SSBN 600) and USS ABRAHAM LINCOLN (SSBN 602). The first reactor compartment disposal was completed on USS PATRICK HENRY (SSN 599; former SSBN 599) in 1986. Since then the shipyard has completed disposal of reactor compartments and recycling of the remaining hulls on numerous submarines.

3.2.3 Site Activities

Puget Sound Naval Shipyard is a large industrial complex capable of providing the full range of industrial, manufacturing, and technological processes required for overhauling and repairing the modern high technology warships of the U.S. Navy. This includes maintenance, refurbishment, overhaul, refueling, and upgrading of submarines and surface ships. Recently, deactivation and disposal of nuclear-powered submarines has become a major activity.

In the specific case of Naval Nuclear Propulsion Program work, which is the focus of Volume I of this HRA, all of the engineering disciplines, trade skills, quality assurance inspectors, and radiological control personnel are available to accomplish electrical and mechanical service to nuclear propulsion plants. These range from simple valve repairs to refueling of the nuclear reactor. A few of the typical services performed are listed below:

- Minor valve repair
- Major valve overhaul or replacement
- Piping system repair or alteration
- Calibration of mechanical and electrical measuring equipment
- Motor and generator overhaul
- Repair and calibration of electrical equipment
- Test and inspection of components and systems
- Off-hull resin discharge
- Refueling

Numerous activities support this work such as nuclear engineering and planning, supply, radiological controls, quality assurance, machine shops, and administrative groups required to plan and execute tasks as complex as overhauling a nuclear-powered warship.

3.3 Site Description

3.3.1 Site Land Use

The physical features of the shipyard are discussed above and shown in Figure 3-4. About 95 percent of the land area within the boundaries of the shipyard is covered by structures or is paved with concrete and asphalt. The shipyard is divided internally into a Controlled Industrial Area and a non-industrial area (dashed line on Figure 3-4).

All of the piers, drydocks, and work facilities used to accomplish Naval Nuclear Propulsion Program work are within the Controlled Industrial Area. Radioactive material shipments traverse the non-industrial area but are stored within the Controlled Industrial Area. As a result of this division, the non-industrial area of the shipyard is not considered a potential source of NNPP radioactivity entering the environment.

Since most of the work that is accomplished on the reactor plant is done onboard the ship, the shipyard facilities dedicated to radiological work are relatively small. Section 5.5 lists the facilities within the Controlled Industrial Area used for radiological work and used to store radioactive material. The primary radiological work facilities are contained within Buildings 839 and 880 and total less than 25,000 square feet.

The remaining buildings in the Controlled Industrial Area are shop areas, warehouses, and administrative areas that do not contain radiological material associated with the Naval Nuclear Propulsion Program. Open paved areas are used for storage of non-nuclear materials and large equipment associated with ship repair functions.

3.3.2 Demography and Adjacent Land Use

The shipyard is within the city of Bremerton. The city of Bremerton is primarily residential and commercial. Beyond city limits the county is primarily residential/semi-rural. Figure 2-11 of Reference 3 is a detailed color-coded land use map of Kitsap County.

The population of Kitsap County in 1990 was 189,731. The following table of estimated population since 1980 shows a pattern that is largely caused by variations in Naval shipboard personnel. The estimates were made on April 1 of each year. The City of Bremerton population is included in the county total population.

Table 3-1
Kitsap County Population

Year	Kitsap County	City of Bremerton
1980	147,152	36,208
1981	156,800	37,000
1982	158,500	35,475
1983	161,600	35,475
1984	162,500	35,475
1985	167,800	37,760
1986	164,500	33,420
1990	189,731	37,730

Bremerton's share of Kitsap County's population is now about 20 percent. Smaller but more rapidly growing population centers include Poulsbo, Port Orchard, Winslow, and Silverdale. Since the development of the Naval Base in Bangor (Subbase Bangor), there has been a slight movement of the center of population northward.

As of 1986, about 6 percent of the county's population was active-duty military personnel. Current estimates are not available, but for 1980 it was estimated that 18 percent of the county population were active military personnel and their dependents, 8.5 percent were retirees and their dependents, and 10 percent were civilians employed by the Navy (mostly at PSNS).

The population of Kitsap County and other counties and cities surrounding Kitsap County are presented in Reference 3, Appendix H-1, Population Data Pertinent to HRS Scoring.

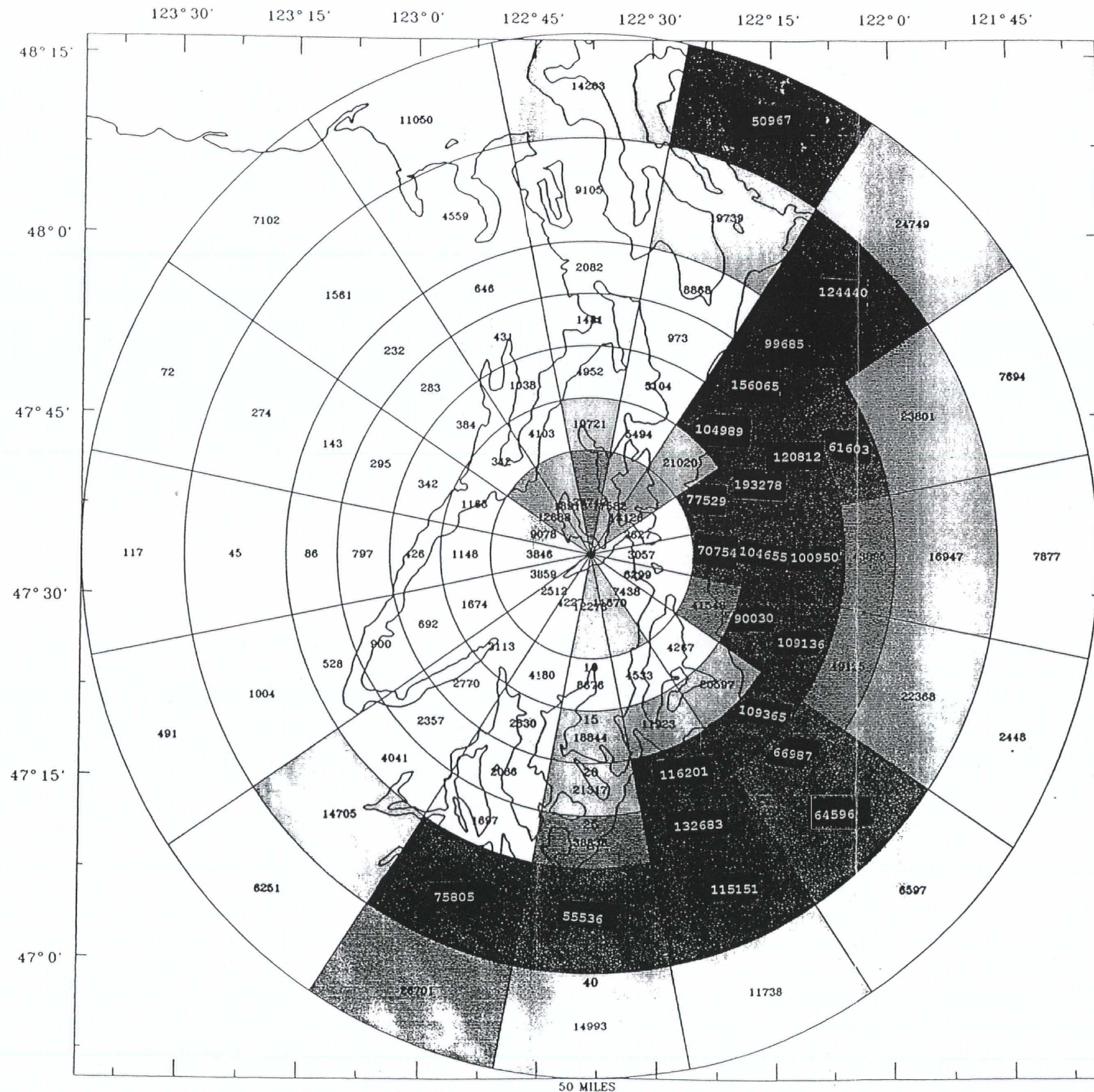
At the time of the 1990 census, approximately 2.98 million persons resided within the 50-mile radius from the shipyard, with 155,942 within 10 miles and 10,076 within 1 mile of the shipyard.

Figures 3-5 and 3-6 are computer generated constructs of 7.5 minute maps with the population by standard zone and sector divisions overlain. A zone is a 22.5 degree arc with Zone "A" centered on geographic north and Zones B, etc., increasing clockwise. A sector is a one-mile, five-mile, or ten-mile annular segment. Population data is based on the 1990 census data.

1990 Regional Population - PUGSND

POPULATION COUNT BY SECTORS AND ANNULI - PUGET SOUND

1990 Census



Sector (0-10)	Population
N	26742
NNE	17582
NE	13126
ENE	2627
E	3057
ESE	6299
SE	7438
SSE	11670
S	12278
SSW	4227
SW	2512
WSW	3859
W	3846
WNW	9078
NW	12688
NNW	18913

Miles	Population	Cumulative Population
0-10	155942	155942
10-15	260270	416212
15-20	562854	979066
20-25	743449	1722515
25-30	510609	2233124
30-40	549636	2782760
40-50	193050	2975810

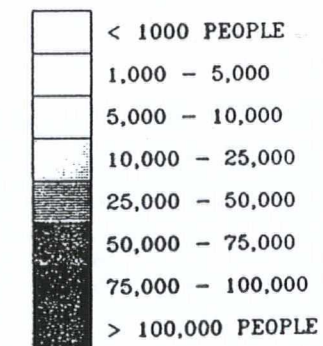
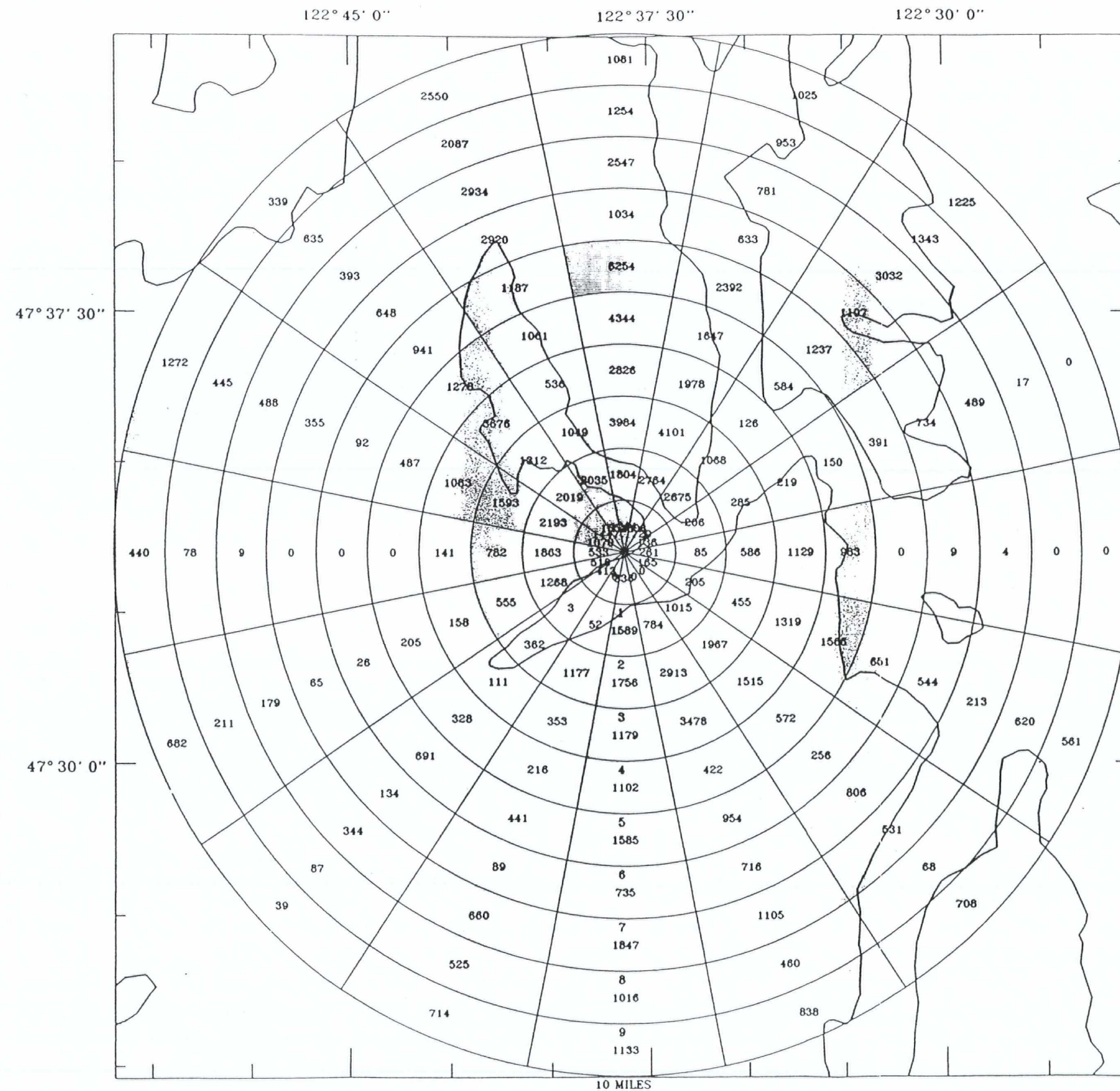


Figure 3-5
Population Density Map
50 Miles

1990 Local Population - PUGSND

POPULATION COUNT BY SECTORS AND ANNULI - PUGSND

1990 Census



Sector (0-1)	Population
N	1614
NNE	1308
NE	729
ENE	136
E	261
ESE	165
SE	0
SSE	0
S	336
SSW	0
SW	413
WSW	510
W	533
WNW	1070
NW	1447
NNW	1554

Miles	Population	Cumulative Population
0-1	10076	10076
1-2	21560	31636
2-3	23945	55581
3-4	19827	75408
4-5	14945	90353
5-6	17098	107451
6-7	10529	117980
7-8	15556	133536
8-9	9799	143335
9-10	12607	155942

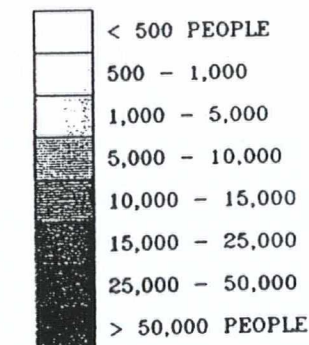


Figure 3-6
Population Density Map
10 Miles

Land use around the shipyard is commercial or residential. A one-mile radius circle includes the business district and adjacent residential areas of the city of Bremerton. Olympic College is located approximately one mile north of the shipyard. The city of Port Orchard (which includes the community known as Annapolis) is located approximately one mile south of the shipyard across Sinclair Inlet.

3.3.3 Physical Characteristics

This section describes the geology, seismology, and geohydrology of the region around the shipyard as they relate to infiltration of contaminants into ground waters, mobility and transport via the ground water, and confining features that preclude area-wide distribution of introduced potential contaminants.

3.3.3.1 Geology

PSNS is within the Puget Sound Lowland, a geologically active area typified by earthquakes, volcanism, and mountainous uplifts. Compression mountain-building processes caused by partial subduction of the Juan de Fuca plate beneath the North American Plate resulted in the uplift of the Olympic Mountains to the west. The Puget Sound Lowland originated as a down-dropped crustal block between the Olympic Mountains and the older Cascade Mountains to the east. Before the Pleistocene continental and alpine glaciation, the Puget Sound Lowland probably contained a large river valley draining to the north and west into what is now the Strait of Juan de Fuca. Pleistocene glaciation of the Puget Sound Lowland produced the arms and bays of Puget Sound. Although the Sound is generally deep throughout its length, shallow sills divide it into distinct cells with partially restricted bottom circulation.

Puget Sound geologic materials include Tertiary basaltic volcanic and clastic sedimentary rocks, as well as Quaternary unconsolidated glacial and interglacial sediments. The Tertiary volcanic and sedimentary rocks are abundant in the Olympic Mountains and originated on the floor of the Pacific Ocean.

Most of the geologic material in Kitsap County is glacial deposits. The Kitsap Peninsula is the remnant of a glacial drift plain. Volcanic bedrock outcrops near the south end of Sinclair Inlet and at Gold Mountain south and west of Bremerton. Sedimentary bedrock outcrops on the south end of Bainbridge Island and at the adjacent tip of the peninsula east of Bremerton. Figure 3-7 is a surficial geologic map of the PSNS area. Table 3-2 is a stratigraphic column for the county.

Figure 3-7
Surficial Geology of PSNS and Vicinity

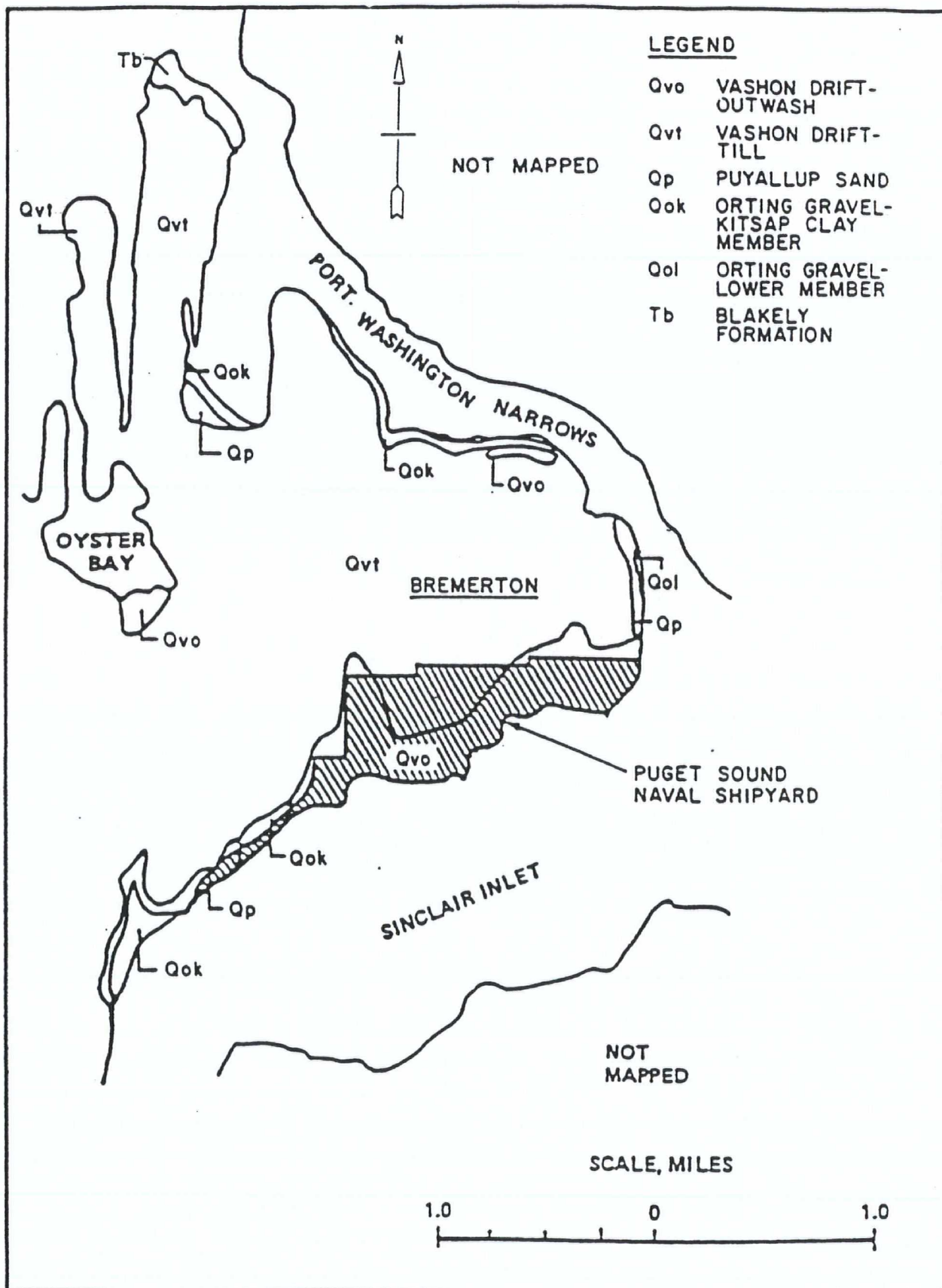


Table 3-2
Stratigraphic Column for Kitsap County, Washington

Quaternary
Recent

Qal: Alluvium -- In places includes beach deposits of sand and gravel in the zone between the shoreline (line of mean high tide) and the upper edge of the beach, which is a short distance inland from the shoreline.

Pleistocene

Qvo: Vashon Drift -- Recessional outwash, discontinuous deposits of silt, sand, and gravel up to 100 feet thick, deposited by glacial melt water streams.

Qvol: Vashon Drift -- Gorst Creek outwash, principally fine-grained sand and silt in the Gorst Creek Valley, thickness not known. Similar outwash deposits in the Burley and Blackjack Valleys are not differentiated from the underlying Puyallup sand.

Qvt: Vashon Drift -- Till, a hard gray mixture of clay, silt, sand, and gravel, as much as 80 feet thick. Deposited primarily as ground moraine. Advance outwash is included with the Puyallup sand.

Qp: Puyallup Sand -- Principally stratified sand as much as 300 feet thick. Contains irregular lenses of fine gravel, silt, and clay. Underlies the Vashon Drift throughout most of Kitsap County. Formation as mapped includes advance outwash of the Vashon Drift; discontinuous deposits of unconsolidated silt, sand, and gravel up to 50 feet thick.

Qok: Orting Gravel -- Kitsap clay member; principally layered clay and silt, as much as 200 feet thick, contains some sand, gravel, till, and peat strata.

Qol: Orting Gravel -- Lower member; stratified sand and gravel, as much as 300 feet thick. Generally stained buff to orange in outcrop.

Qa: Admiralty Drift -- Principally massive blue clay and silt; contains some sand, gravel till peat or lignite, and volcanic ash. The Admiralty Drift is 400 feet or more thick; its top usually occurs near or below sea level.

Tertiary
Oligocene

Tb: Blakely Formation -- Marine sandstone, shale, and conglomerate exceeding 8,560 feet in thickness.

Eocene

Tv: Volcanic Rocks --Sequence of basalt flows exceeding 6,000 feet in thickness.

3.3.3.2 Soils

Kitsap County has four basic soil types:

1. Soils underlain by cemented hardpan or bedrock substrate. These include the soils of the Alderwood, Sinclair, Edmonds, and Melbourne series.
2. Soils with permeable, distinctly stratified substrata, such as the Everett, Indianola, and Kitsap series, and undifferentiated alluvial soil. These soils are coarse and have good internal drainage.
3. Organic soils represented by small, widely scattered areas of Greenwood, Rifle, and Spalding peats and muck.
4. Soils having little or no agricultural or building potential. Typical land forms include rough mountainous land, steep broken land, coastal beaches, and tidal marshes.

The natural topography of the shipyard has been altered significantly from its original condition. Portions of the upland areas of the complex were cut to fill marshes and create level land. The resulting fill material was predominantly a silty, gravel sand with occasional pockets of silts and clays. These filled lowland soils are subject to liquefaction during an earthquake. The surface of the filled areas is a solid layer of earth frequently of the Alderwood soil series. The remaining areas of natural soils vary from dense glacial till to soft bay mud and peat. The upland soil has been classified as Alderwood loam, a stiff hardpan soil with low permeability. The lowland soils are deep and cohesionless.

3.3.3.3 Ground Water Sources and Uses

There are upper and lower sand and gravel aquifers within Kitsap County.

The upper aquifer is bounded to the north by elevated topographic features, to the west by igneous rock basalt formations, and to the south and east by Sinclair Inlet which is one mile wide and 4.3 miles long. The upper aquifer overlies a silt and clay aquitard throughout the area and the base of the aquifer ranges from near sea level to 200 to 300 feet above mean sea level. The saturated thickness of this aquifer ranges from 20 feet to more than 200 feet. Wells in this unconfined aquifer have water-level elevations ranging from near mean sea level along the coast to 240 feet or more above mean sea level in the interior uplands.

The lower aquifer occurs at elevations ranging from slightly above mean sea level to approximately 300 feet below mean sea level. The aquifer thickness ranges from a few feet to more than 300 feet. The confining aquitard ranges in thickness from a few feet to more than 200 feet. The piezometric surface of the lower aquifer is above the top of the aquifer and, in lowland areas, the wells are flowing artesian.

Ground water flow in the vicinity of the shipyard

The movement of the ground water in both aquifers is in the direction of Sinclair Inlet (to the south and east).

Ground water elevations have been measured during various geotechnical investigations conducted in the lower elevations of the shipyard. A quantitative review of these data indicates that the fill areas are hydraulically connected to Sinclair Inlet; that the configuration of the ground water contours in the low areas is projected to reflect the outlines of the old shoreline; and that the water table rises steadily with increasing distance from the existing shoreline. Ground water flows from north to south toward the Inlet. The elevation of the water table in the low areas of the shipyard fluctuates because of the seasonal precipitation rates (9.4 inches in December versus 0.6 inches in August); tidal effects; and operation of drydock dewatering systems.

The drydock dewatering systems have been postulated as producing the greatest change on local flow patterns and ground water gradients, but these changes have not been quantified. Dewatering increases the flow of outside water toward the shipyard, and would thus not disperse any potential contaminants into the ground water.

Ground water quality

The quality of most ground water throughout the area is good to excellent. The relatively high annual precipitation rate (45 inches per year) results in low dissolved solids in the ground water, typically less than 150 milligrams per liter (mg/L). However, shallow wells very near the shoreline may have high chloride concentrations because of saltwater intrusion.

Ground water resources

Many of the wells that tap into the upper and lower aquifers within the area of the Kitsap Peninsula are used for irrigation and for domestic, industrial, and public water supplies. There is no commercial or recreational use of the water wells within a 4-mile radius of PSNS.

Wellhead protection areas

A wellhead protection area is defined by Section 1423 of the Safe Drinking Water Act as the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field. At the time of this report, wellhead protection areas have not been established by the State of Washington or Kitsap County.

However, there are no drinking water wells in PSNS. Potable water is supplied to PSNS and most of the surrounding area by the City of Bremerton Water Department. Based on ground water flow, any potential contaminants that infiltrated into ground water at PSNS would be expected to discharge into Sinclair Inlet; it is not credible that they might affect upstream wellheads.

3.3.3.4 Surface Water Sources and Uses

Approximately 100 miles of marine shoreline in Kitsap County are created by Puget Sound and Hood Canal. Dyes Inlet, Sinclair Inlet, Port Washington Narrows, and Port Orchard Bay are interconnecting water bodies within the Puget Sound System and connect with Puget Sound proper through Rich Passage and Agate Passage. The City of Bremerton, alone, has approximately 11 miles of marine shoreline.

Figure 3-8 (Surface Drainage/Ocean Currents) shows surface drainage, water depth, wave action, and direction of littoral (near shore and beach) drift in Sinclair Inlet. PSNS is divided into two different watersheds with drainage in opposite directions, as shown on Figure 3-8. The partial drainage area for each watershed in PSNS is approximately 175 acres.

Numerous lakes dot the county's landscape, most of which are small and shallow. Kitsap Lake, northwest of Bremerton, is one of the largest at 238 acres. Recreation and public water supply are the primary uses of the lakes and reservoirs.

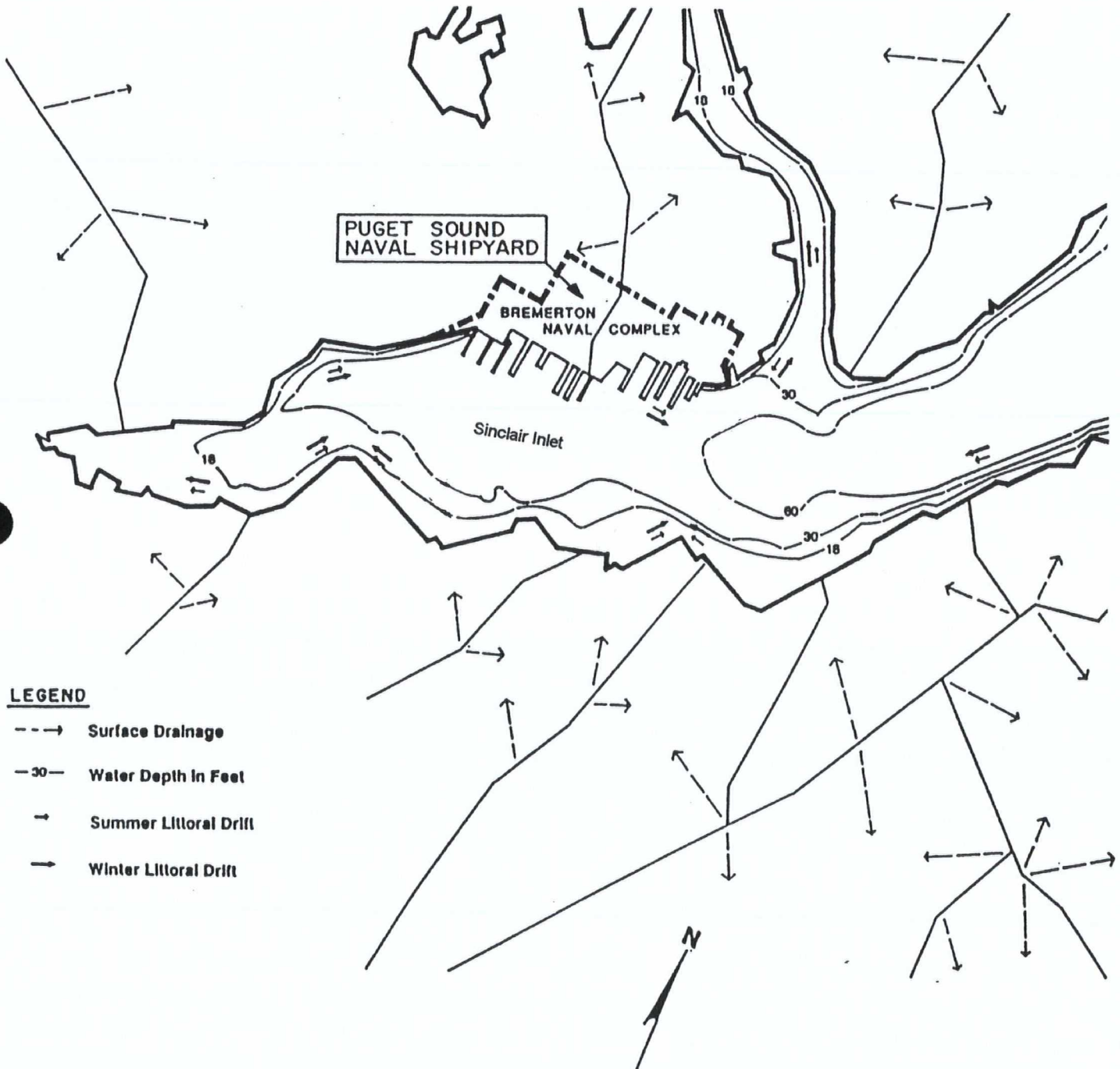
The area's typical lowland-type streams and creeks with moderate gradients drain relatively small watersheds into Puget Sound from the east half of Kitsap Peninsula. In contrast, the watersheds of the west half of Kitsap Peninsula are much larger and drain into Hood Canal. The highest stream/creek flow rates are from November to February, and the lowest flows are during August and September. The streams are not large enough to pose significant flood hazards, but flooding of the low lying areas adjacent to these streams does occur during extraordinarily high tides or due to storm-related wave action.

There are no perennial streams or freshwater bodies within the shipyard boundaries. The ground surface in the industrial area is extensively paved (approximately 95%), and a storm sewer system collects surface drainage and discharges it to Sinclair Inlet. Numerous small streams discharge directly into the Inlet along the southern and western shores of the Inlet. The total volume of freshwater input to the Inlet, including direct precipitation and ground water, is low compared to the saltwater input from tidal flow.

Sinclair Inlet is a tidally dominated, non-stratified, saline body of water. The Inlet experiences a semidiurnal, mixed-type tide with a mean range of 11.7 feet. Circulation in the Inlet is driven by tidal currents, which are generally weak with a slow outward transport of water. Littoral drift, which refers to the movement of materials such as sand and gravel along the near shore or beach environments under the influence of tidal action, occurs at a much greater rate in the winter than in the summer.

Sinclair Inlet is rated as a Class A (excellent) body of water according to the classification listed in the Washington Administrative Code (WAC) 173-201. Under this classification, water uses to be protected include anadromous salmon migration and rearing, commercial fish and shellfish reproduction and harvesting, boating, fishing, aesthetics and water contact recreation, industrial water supply, and navigation. However, Sinclair Inlet has been closed to shellfish harvesting since 1982 because of bacterial contamination.

Figure 3-8
Surface Drainage/Ocean Currents



3.3.3.5 Water Supply

The Bremerton Water Department supplies water to the surrounding area including the shipyard. The city uses a combination of wells and surface water to provide water to its customers. Approximately 30 percent of the total water provided is used by PSNS. Eighty percent of the City's water comes from the Union River Reservoir. The remaining 20 percent is supplied from Anderson Creek reservoir and several deep, large-volume wells (i.e., into the lower aquifer). In essence, the entire area population of Bremerton drinks from both surface water and ground water sources, because all the water sources are combined.

Reference 3 states that there are no interconnections between the upper and lower aquifers and that there are no drinking water wells that draw from the same upper aquifer that exists under the shipyard.

Table 3-3 lists public water supply sources within a 4-mile radius of PSNS. The well data used to make Table 3-3 was compiled from Reference 3, Appendix H-3, Existing Well Data Pertinent to HRS Scoring. Before 1974, the state did not require documentation of water supply wells.

Several deep, large volume wells tap into the lower aquifer in the area of concern on the Kitsap Peninsula. Approximately 5,000 people are served by the deep municipal wells located in the Port Orchard area. The population estimate available for the greater Bremerton area for 1990 is approximately 148,974. The nearest private well identified by Reference 3 is at the Clam Bake restaurant 1.2 miles south of the shipyard, west of Port Orchard across Sinclair Inlet.

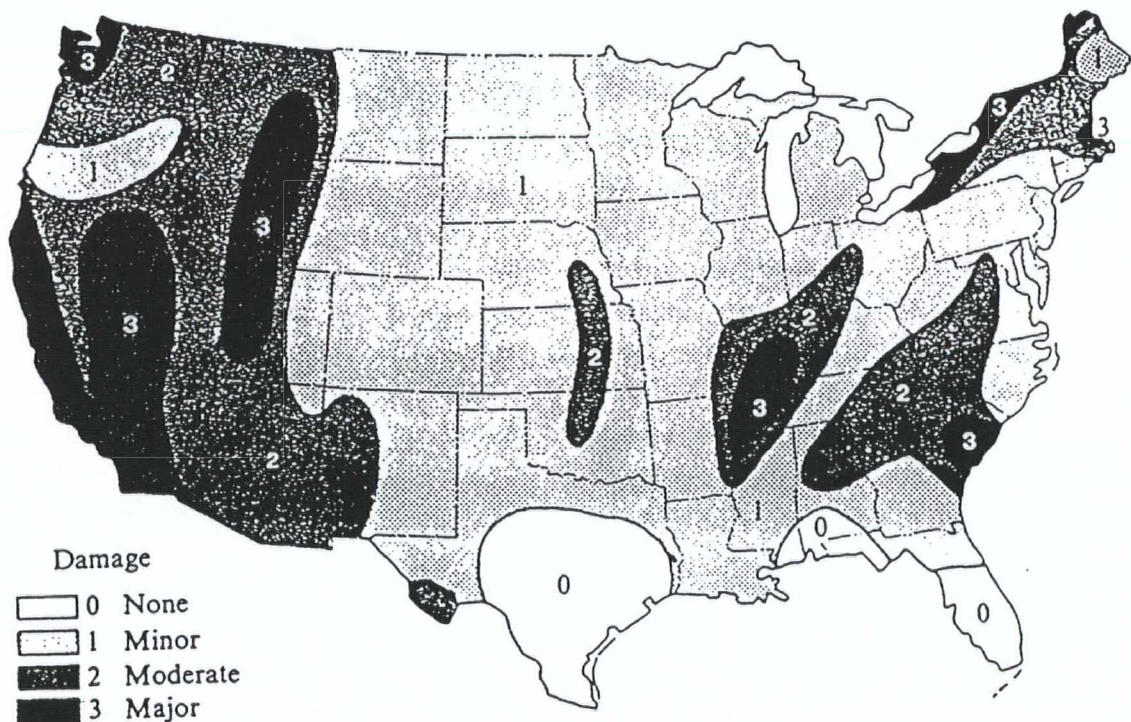
Table 3-3
Public Water Supply Sources Within a 4-Mile Radius of PSNS

Source	Type	Well Depth(feet)	Flow Rate GPM
Bremerton Water Department			
Gorst Creek	Surface-Emergency	NA	1,795
Well 1	Well-Emergency	260	Unknown
Well 2	Well-Standby	236	1,200
Well 3	Well-Standby	316	1,200
Well 5	Well-Standby	569	Unknown
Well 6	Well-Standby	535	Unknown
Well 7	Well-Primary	627	450
Well 8	Well-Primary	572	600
Well 13	Well-Primary	273	530
Well 14	Well-Primary	278	340
Well 9	Well-Primary	882	225
Well 16	Well-Standby	400	125
Port Orchard Water Department			
Well 6	Well-Primary	832	250
Well 7	Well-Primary	804	700
08200R	NA	NA	1,000
Well 8	Well-Primary	500	450
Well 5	Well-Emergency	500	100
Annapolis Water District			
Well 1	Well-Primary	1130	450
Well 5	Well-Primary	1031	360
Well 7	Well-Primary	1050	350
Well 16	Well-Primary	300	330
Well 8	Well-Primary	686	270
Well 9	Well-Emergency	350	180
Well 10	Well-Primary	350	110
Well 11	Well-Primary	660	725
Well 13	Well-Primary	56	80
Well 14	Well-Primary	660	605
Well 15	Well-Primary	157	80
Well 2	Well-Primary	700	240
Well 17	Well-Primary	800	400
Manchester Water District			
22M01	Well-Primary	116	150
29Q01	Well-Primary	250	270

3.3.3.6 Seismology

Seismic risk maps published by the U.S. Coast and Geodetic Survey place Kitsap County and Puget Sound Naval Shipyard in risk zone 3, indicating an expectancy of major destructive earthquakes. There have been approximately 200 earthquakes since 1840, but there is no known surface faulting. The most recent earthquakes of high magnitude in the region were near Olympia in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale). Two known fault traces have been identified in the county: the Kingston-Bothell trace in the northern portion of the county and the Seattle-Bremerton trace located a few miles north of Bremerton.

Figure 3-9
Seismic Risk Map for Conterminous U.S.



The map divides the U.S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.

Reference: Robert J. Foster, "Physical Geology," Charles E. Merrill Publishing Company, Second Edition, 1975

3.3.4 Climatology

Because of its proximity to the Pacific Ocean and the influences of Puget Sound, the Kitsap Peninsula has a maritime climate, with generally cool, dry summers and mild, wet winters. Winds from the south and southwest generally bring rain, whereas winds from the north and northwest bring clear weather. Occasionally during winter, cold air flowing south from Canada brings subfreezing temperatures.

The average summer temperature is between 70° and 80°F during the day and 50° to 60°F at night. Temperatures during winter range from 40° to 50°F during the day and 30° to 40°F at night. Temperatures below 0°F or above 100°F seldom occur.

Southwesterly winds prevail during the fall and winter. Northwest winds prevail during spring and summer. Wind velocity from June to September ranges from 0 to 9 miles per hour and from October to May it often reaches 20 miles per hour. The annual mean precipitation in Kitsap County varies from a high of 75 inches to a low of 25 inches. Bremerton's average annual rainfall is approximately 45 inches. The maximum precipitation occurs in December (9.4 inches) and the minimum in August (0.6 inch). Approximately 85 percent of the precipitation occurs between October and April. Summer rainfall is limited to isolated shower activity. Winter snowfall is generally light and seldom exceeds a depth of 3 to 6 inches.

Five to eight days a month are clear or partly cloudy in the winter. In the summer, clear or cloudy days increase to about 20 per month. Fog occurs an average of 10 percent of the time, but is as high as 20 percent in October and November.

Puget Sound Naval Shipyard is not located in the 100-year flood plain. According to the Federal Emergency Management Agency (FEMA), lands at or above an elevation of 10 feet above mean sea level are considered to be above the 100-year flood plain. All shipyard elevations are greater than 10 feet above mean sea level.

4.0 Description of Operations

4.1 Background on Navy Organizational Activities

4.1.1 Naval Facilities Engineering Command (NAVFAC)

NAVFAC is responsible for taking the lead in negotiating Federal Facilities Agreements (FFAs) with EPA regional offices and states.

4.1.2 Naval Nuclear Propulsion Program

The Naval Nuclear Propulsion Program is a joint Department of Energy (DOE)/Department of the Navy program comprised of military and civilian personnel who design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities. The Program has a broad reach, maintaining responsibility for all aspects of Naval nuclear propulsion plants (including control of radiation and radioactivity) from cradle to grave. It is completely separate from the rest of the Navy and DOE activities that deal with radioactivity. Program responsibilities are delineated in Presidential Executive Order 12344 of February 1, 1982, and enacted as permanent law by Public Law 98-525 of October 19, 1984 (42 U.S.C. 7158).

Program elements include:

- * The Navy's nuclear-powered warships;
- * Research and development laboratories;
- * Contractors responsible for the design, procurement, and construction of propulsion plant equipment;
- * Shipyards that construct, overhaul, and service the propulsion plants of nuclear-powered vessels;
- * Navy nuclear support facilities and tenders;
- * Nuclear power schools and Naval Reactors training facilities; and
- * The Naval Nuclear Propulsion Program headquarters organization and field offices.

Admiral H.G. Rickover developed the Naval Nuclear Propulsion Program at the end of World War II, with a commitment to technical excellence and an organization staffed by experienced professionals dedicated to designing, building, and operating Naval nuclear propulsion plants safely and in a manner that protects people and the environment. Executive Order 12344 and Public Law 98-525 capture the concepts and principles central to the Program's accomplishments.

Dealing with radioactive materials and ionizing radiation safely and responsibly has been an integral part of the NNPP from the beginning. It was recognized that the usefulness of nuclear-powered warships would be seriously hampered if operational restrictions were necessary because of radiological concerns. Therefore, the reactor plants were designed and continue to be operated such that the radiological impact on people and the environment is minimized. The NNPP established limits for releases to the environment which were well below limits applied to

operation of commercial nuclear power plants (see Section 5.1.1.1). NNPP policy has been to control radioactivity such that radiological environmental impact is insignificant compared to natural radioactivity levels in the environment. From the start of the Naval Nuclear Propulsion Program, the policy has been to reduce to the minimum practicable the amounts of radioactivity released into the environment.

4.2 Radioactivity from Naval Nuclear Propulsion Plants

Naval nuclear propulsion plants differ from commercial power generating reactors in several important ways with respect to potential environmental impact. They are considerably smaller both in physical size and power output. To assure safe operation in close proximity to operating crews under possible high shock loading of battle conditions, the reactor plants are much more durable. Leakage of fission products into the cooling system, or leakage of the cooling system, are not compatible with ship operation and are not tolerated. Over 40 years experience with Naval nuclear propulsion plants has shown that fission products are contained in the fuel elements. This characteristic significantly reduces the potential for radiological environmental impact.

In the shipboard reactors, pressurized (non-boiling) water circulating through the reactor core picks up the heat of nuclear reaction. The reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The secondary system water is turned into steam, which is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor cooling water expands as a result of being heated up to operating temperature; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

While fission products produced in the fuel, including iodine and the fission gases krypton and xenon, are retained within the fuel elements, it is true that trace quantities of naturally occurring uranium impurities in the surface of reactor structural materials release small amounts of fission products to the reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides comprises only a small fraction of the total long-lived gamma radioactivity releases discussed elsewhere in this section of this report.

The primary mechanism by which environmental releases of NNPP radioactivity occur include: (1) inadvertent releases of small volumes of liquids (or pre-1972 historical releases) to the harbor, as discussed in Section 5.1.1; (2) inadvertent releases of small amounts of liquid or solid material (or, very rarely, gases), as listed in Section 5.1.3; (3) the particulate output from HEPA-filtered air exhausts at work areas, as discussed in Section 5.1.2; and (4) the release of trace quantities of fission product gasses and carbon-14 gaseous products from primary coolant which has been depressurized (including that which is removed from ships for processing into controlled pure water, as discussed in Section 5.1.1.1). Note that ships are prohibited from discharging reactor cooling water overboard in the vicinity of shore; hence, shipboard reactor operations are not considered a significant potential source of environmental contamination.

4.2.1 Cobalt-60

The principal source of radioactivity in liquid effluents or encountered during maintenance work is trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives of approximately one day or greater in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, nickel-63, niobium-95, zirconium-95, tantalum-182, manganese-54, cobalt-58, and cobalt-60. The most predominant of these is cobalt-60, which has a 5.3 year half-life. Cobalt-60 also has the most restrictive concentration limits, as listed in Reference 5. Therefore, cobalt-60 is the primary radionuclide of interest for Naval nuclear propulsion plants.

(Half-life is the time required for a radioactive material to decay to one-half its starting activity level. For example, 30 pCi/g of cobalt-60 would be 15 pCi/g after 5.3 years, 7.5 pCi/g after 10.6 years, 3.75 pCi/g after 15.9 years, etc.)

4.2.2 Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and as a result of certain other nuclear reactions. Although tritium has a 12.3 year half-life, the radiation produced is of such low energy (weak beta; no gamma) that the Reference 5 radioactivity concentration limit for tritium is at least one hundred times higher than for cobalt-60. This tritium is in the oxide form (i.e., water) and is chemically indistinguishable from normal water; therefore, it does not concentrate in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference 6 estimates the natural production rate of tritium would produce a global equilibrium inventory of between 28 million and 70 million curies. Table 3-3 of Reference 6 shows that 65 percent of the global inventory occurs in oceanic waters. These values yield an oceanic inventory of about 18 million to 45 million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released annually from all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 200 curies. Most of this has been into the ocean greater than twelve miles from shore. The total tritium released annually from the entire nuclear Navy is less than single electrical generating nuclear power stations typically release each year. Total tritium released annually into harbors within twelve miles of shore is less than one curie. Appendix B of Reference 6 reports an estimated dose due to natural tritium in the environment of between 1.0 μ rem/yr and 1.5 μ rem/yr. In comparison to the millions of curies naturally occurring in the oceans, the 200 curies of tritium per year released from nuclear ships is insignificant to both the global inventory and to the annual dose due to the environmental tritium. Therefore, tritium has not been combined with the data on other radionuclides in other sections of this report.

4.2.3 Carbon-14

Carbon-14 is also formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oxygen. This carbon is in the form of a gas, primarily methane and ethane, although some insoluble carbonates may be present; following reprocessing of reactor coolant (to make controlled pure water), it is possible some carbon-14 has been converted to carbon dioxide. Carbon-14 decays with a half-life of 5,730 years; however, only low energy beta radiation is emitted as a result of this decay process. As a result, the Reference 5 radioactivity concentration limit for carbon-14 in its chemical form in air is sixty times higher than for cobalt-60.

Carbon-14 occurs naturally in the environment. It is generated from cosmic radiation interactions with nitrogen and oxygen in the upper atmosphere and oxidized to form carbon dioxide. Appendix B of Reference 6 states that "weapons testing has essentially doubled the atmospheric inventory of carbon-14 present from natural sources." Carbon-14 is chemically indistinguishable from other isotopes of carbon. The carbon dioxide diffuses and convects throughout the atmosphere and enters the earth's carbon cycle (i.e., achieving equilibrium concentrations in all living organisms; this is what permits "carbon dating" of deceased organisms, since carbon-14 in dead matter decays and is not replenished).

The earth's carbon-14 inventory is estimated to be about two hundred and fifty million curies. The total amount of carbon-14 released annually from the operation of all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 100 curies, most of which is released at sea beyond twelve miles from shore. Since the inventory of naturally occurring carbon-14 is millions of curies, releases from Naval nuclear reactors do not result in a measurable change in the background concentration of carbon-14.

Typical annual releases of carbon-14 at PSNS are about 1 curie per year, virtually all as a gas. This is much less than the approximately 7 curies per year discharged by the typical commercial nuclear power plant per Reference 7. These gaseous releases are dispersed in the atmosphere and are not concentrated in the environment. Calculations using the EPA COMPLY computer code indicate that the resulting dose is less than 1.0 mrem per year. Furthermore, a study around a large civilian nuclear power plant showed no measurable carbon-14 in downwind foliage (Reference 8). For these reasons, carbon-14 is not judged a remediation concern, and carbon-14 data has not been combined with the data on other radionuclides in other sections of this report.

4.3 Type of Activities

Navy facilities authorized to perform radioactive work associated with Naval nuclear propulsion plants perform a wide range of maintenance, repair, and upgrading activities. Some facilities, including PSNS, also refuel reactor plants. Refueling involves removal of spent fuel into special shipping containers and installation of new fuel. No work on or processing of fuel is performed at these facilities. Radioactive materials encountered during reactor plant work include reactor coolant that is processed and reused, reactor plant components (including removed and/or unusable components), tools and equipment used to perform the work, reusable (laundered)

contamination control clothing, and contamination control waste products such as plastic bags, tape, plastic bottles, and impervious fabrics.

Trade skills required for reactor plant work are the same as for typical shipyard operations. Machinists, pipefitters, shipfitters, welders, sheet metal workers, electricians, painters, fabric workers, and riggers perform the work. Work is directed by engineers and monitored by inspectors and radiological control technicians. The primary differences from other work are the extremely high quality standards and the interaction with radiation and radioactive materials. For example, it is common to train personnel on uncontaminated mockups prior to performing work on contaminated systems, to minimize exposure and help preclude errors.

Qualified Navy crews also operate the reactor plants for limited training and to test the plants following maintenance.

4.4 Control of Radioactivity

A major objective in the performance of Naval nuclear propulsion plant work is avoiding the potential for releases of low level radioactivity into the environment. From the beginning of the NNPP, radiological work has been performed under strict controls to preclude the spread of contamination, by containing radioactivity at the source to the smallest practicable area or volume. Facilities where work on radioactive materials is performed are specifically designed to contain radioactivity. Design criteria include impervious walls, easily decontaminated surfaces, absence of floor drains, and ventilation systems with High Efficiency Particulate Air (HEPA) filtered exhausts to maintain a negative pressure in work areas. The HEPA filters are 99.97% efficient at removing 0.3 micron particles. The filtered exhausts are monitored with an Environmental Monitoring System; results of this monitoring are discussed in Section 5.

In addition, most work on radioactive materials is performed inside Contamination Containment Areas inside these facilities with all the same features as the building. This provides double isolation of radioactivity from the environment. In the event of a loss of containment (e.g., a liquid spill or a puncture in a containment), immediate action is taken to isolate and correct the problem, and to sample/survey to verify complete recovery.

Radioactive material in storage areas is packaged to contain any loose radioactive contamination and is surveyed prior to transfer by radiological control personnel to ensure the outside of the packaging is not contaminated. Radioactive material storage areas are surveyed for loose radioactive contamination periodically by radiological control personnel.

Radiological work facilities within Buildings 839 and 880 are designated as Radiologically Controlled Areas. These areas are physically separated from the rest of the building. Access to the Radiologically Controlled Area for both personnel and material is via a control point manned by radiological control personnel. Personnel and material exiting a Radiologically Controlled Area are surveyed for radioactive contamination in portal monitors or with beta-gamma friskers.

All areas within a Radiologically Controlled Area are maintained less than 450 pCi/100 cm² (by swipe analysis), except for those areas designated and specially controlled as Controlled Surface Contamination Areas. Controlled Surface Contamination Areas are maintained at or near 450 pCi/100 cm² even during work on contaminated items. Radiologically Controlled Areas and Controlled Surface Contamination Areas are surveyed frequently by radiological control personnel to ensure that radioactive contamination levels are held below NNPP limits.

A primary design criterion for Naval nuclear propulsion plants was minimal release of radioactivity during reactor operation to avoid the need for operational restrictions while in port. Therefore, there is no significant environmental impact from the small amount of reactor operation for reactor testing at the shipyard.

The NNPP controls radioactivity at the source by using the concept of total containment. This policy minimizes the spread of radioactive contamination to adjacent surfaces and to personnel. Engineered ventilation systems containing HEPA filters, drapes, glovebags, and tents are utilized to accomplish this goal. Any personnel, instructional, or equipment errors that result in even a minor spread of contamination halt the work until the cause is determined and corrective action is taken. This policy and its successful application allow most radiological work to be performed without personal protective clothing or respirators. In addition to permitting work to be accomplished more efficiently, the number and extent of radiological areas requiring release is minimized.

Radioactive materials are either maintained within controlled areas, or are attended or physically secured at all times. Movement of radioactive materials outside controlled areas requires a strict accountability system. All movements are verified by an individual other than the one performing the move.

Routine radiological surveys in and around facilities where work on radioactive materials is performed confirm that controls are effective. Corrective actions are taken immediately in the unusual event that surveys identify unexpected radioactivity. Inadvertent releases are cleaned up immediately (within hours if practicable), and a critique is held to identify and correct the cause of the problem. Detectable radioactivity in uncontrolled areas is not permitted.

The basic policies covering control of radioactivity have not been changed since the beginning of the NNPP. There has been continuous upgrading based on over 30 years of experience. An example of this is development of processing methods to make radioactive liquids reusable as reactor coolant. Other examples of upgrading include improved work facilities, development of improved contamination containment area designs, solid radioactive waste volume reduction, improved radiological analysis of environmental samples, and the extensive use of engineered ventilation systems. Upgraded monitoring methods have not detected problems with the basic control methods which have been used from the beginning of the Program.

4.5 Regulatory Oversight

NNPP radiological controls at PSNS are overseen by Naval Nuclear Propulsion Program headquarters. NNPP headquarters performs on-site biennial audits of all PSNS nuclear work practices, including radiological controls, worker training, quality control, and compliance with work procedures and headquarters requirements. During alternate years, headquarters performs on-site reviews of shipyard radiological controls, in support of the NNPP authorization for shipyard handling of NNPP radiological materials. The NNPP also maintains a field office at the site, to oversee day-to-day activities.

Regulatory interface regarding mixed (radiological and hazardous) waste is addressed in Section 5.3.

5.0 Policies and Results

5.1 Policies and Records Related to Environmental Release of Radioactivity

5.1.1 Liquid Discharges

5.1.1.1 Policy

General

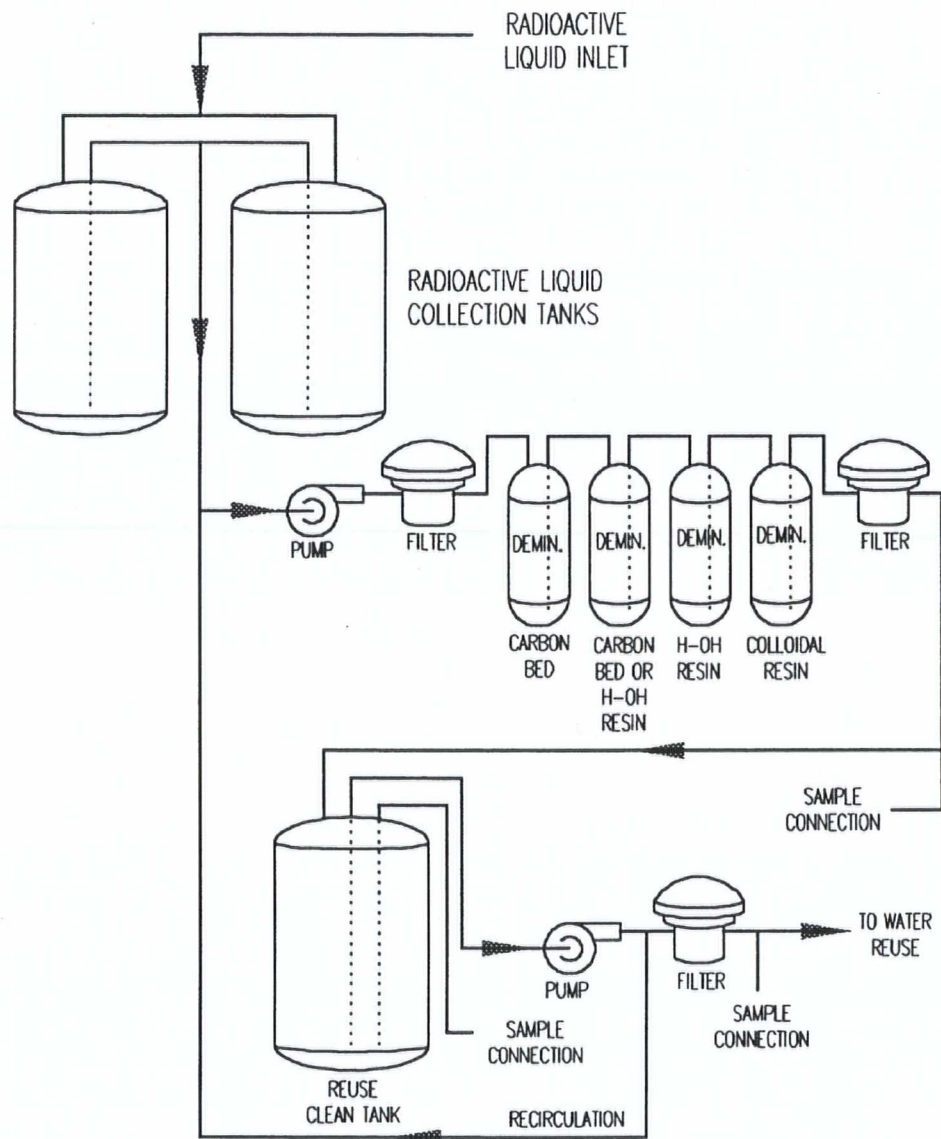
As stated in Reference 9, the policy of the NNPP is to minimize the amount of radioactivity released to the environment, particularly within twelve miles of shore (e.g., including into harbors). This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated into the Environmental Protection Agency in 1970), U.S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences--National Research Council. To implement this policy of minimizing releases, the NNPP has issued standard instructions defining radioactive release limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission.

The policies and procedures instituted by about 1972 remain in place through the present. The total amount of long-lived (half-life greater than one day) gamma radioactivity released into harbors and seas within twelve miles of shore by the entire Naval Nuclear Propulsion Program has been less than 0.002 curie during each of the last twenty-two years. This total is for releases from U.S. Naval nuclear-powered ships and from the supporting shipyards, tenders, and submarine bases, including releases at operating bases and home ports in the U.S. and overseas and all other U.S. and foreign ports which were visited by Naval nuclear-powered ships. This activity level is conservatively reported as if it consisted entirely of cobalt-60, which is the predominant long-lived gamma radionuclide and also has the most stringent concentration limits.

Processing and Reuse of Radioactive Liquids

Radioactive liquids at PSNS are collected in special tanks designed for this purpose and processed through a processing system to remove most of the radioactivity (exclusive of tritium) prior to collection in a clean tank for reuse. Figure 5-1 shows a simplified block diagram of the liquid processing system which consists of particulate filters, activated carbon bed filters, mixed hydrogen hydroxyl resin, and colloid removal resin beds. This type of processing system has been developed and used successfully to produce high quality water containing very low radioactivity levels. The NNPP refers to this as "Controlled Pure Water" (CPW).

Figure 5-1
Simplified Diagram of Typical Radioactive
Liquid Processing System



Even after processing to approximately 10^{-8} $\mu\text{Ci/ml}$, reactor coolant is not discharged into the harbor. Rather, it is returned to ships. To put this CPW in perspective, the Safe Drinking Water Act of 1974 standards established in Title 40 Code of Federal Regulations Part 141 (40 CFR 141) specify that the annual dose equivalent to the total body or any internal organ shall not be greater than 4 millirem/year from man-made radionuclides in drinking water based on continuous consumption. If water containing cobalt-60 at a level of 3×10^{-6} $\mu\text{Ci/ml}$ were consumed continuously for a year, the total effective dose equivalent would equal 50 millirem. This value is derived from Reference 5. This means that if a person's total water intake for a year, including all water in fruit, meat, etc., were 100% CPW at the NNPP limit of 6×10^{-8} $\mu\text{Ci/ml}$ cobalt-60, the cobalt-60 would result in a total effective annual dose equivalent of 1 millirem per year (one-fourth the EPA limit). The dose due to tritium in the water would be about 100 millirem, but since this intake scenario is highly unrealistic, the potential dose to any person is actually very small. Release to the environment of such water would have negligible impact.

Policy Details

Standardized NNPP instructions concerning discharges of radioactive liquids from nuclear-powered ships were first issued in 1958. In 1965, all of the prior instructions were consolidated and incorporated into a technical manual for use by all shipyards in their radiological control programs.

The basic criteria for release limits set in 1958 was that disposal of radioactive liquids should not increase the average concentrations of radionuclides in the surrounding environment by more than one-tenth of the maximum permissible concentrations for continuous exposure listed in National Bureau of Standards Handbook 52, Reference 10.

Measurements showed a dilution of over 100,000 for reactor coolant discharged from a ship. Credit for dilution was reduced to a factor of 1000 to be conservative. By setting the coolant discharge concentration limit at 100 times the Handbook 52 value for specific radionuclides listed, and taking credit for a 1000-fold dilution, the one-tenth criteria was met.

In May 1961, the NNPP release criteria was revised to be one-tenth of the limit of National Bureau of Standards Handbook 69, Reference 11. The Handbook 69 values were subsequently incorporated into Reference 5. 10 CFR 20 continues to serve as the commercial nuclear industry basis for radioactive effluents in air or water through the present. The standard instructions codified in 1965 for use by all NNPP activities were based on the limits of 10 CFR 20, to ensure consistency with commercial standards where practical.

Between 1958 and May 1961, shore activities were allowed to dilute radioactive liquids to less than 3×10^{-5} $\mu\text{Ci/ml}$ prior to discharge. In May 1961, the Program required that radioactive liquids be treated by filtration and ion exchangers to minimize the dilution required to attain the 3×10^{-5} $\mu\text{Ci/ml}$ limit. In December 1965, requirements were modified to prefer additional treatment to attain the allowable concentrations in lieu of dilution.

In addition to the concentration limits discussed above, other limits and conditions were required, including total activity per year, total activity per work shift, tidal conditions at the time of discharge, total gallons discharged, and proper authorizations. These NNPP limits and conditions were more conservative than any other agency's regulations at this time.

The tritium (hydrogen-3) concentration in both reactor coolant and controlled pure water is the same, at about 2×10^{-3} $\mu\text{Ci/ml}$ or less. This is below the 10 CFR 20 sanitary sewer release criteria for tritium which the Nuclear Regulatory Commission uses for sites it regulates. Any such water which entered the harbor would be rapidly diluted and become indistinguishable from background tritium levels, as discussed in Section 4.2.2. If any small volume spilled on land and went undetected, it would be quickly washed into the harbor (e.g., by rainwater, or possibly by entering the shallow ground water system which discharges into the harbor as discussed in Section 3.3.3.3). No environmental mechanism to concentrate this radionuclide exists.

During 1970, shipyards were directed to acquire the capability to collect, process, and reuse reactor cooling water. In June of 1972, the Program regulations directed that discharges of processed liquids could only be made with specific approval of Naval Nuclear Propulsion Program headquarters.

5.1.1.2 Liquid Discharges and Records

The shipyard began its first work on a Naval nuclear-powered ship in 1965. Initially, radioactive liquids were processed on a barge and discharged to the harbor as described above. In addition to the liquid processing system, the barge was also equipped with a laundry system to wash anti-contamination clothing. Laundry water was filtered prior to release. The barge was normally placed in drydock with the ship it was supporting and the discharge connection made to a header pipe along the side of the drydock. Radioactive liquids were also processed and discharged at the Radiological Repair Facility (Bldg. 839) beginning in 1967. Use of the barge system was phased out and Building 839 became the only radioactive liquid processing system in 1971.

A significant portion of the liquid volume discharged to the harbor in the early years originated from laundry operation. In-house laundry was discontinued in 1968. Since 1968, laundry has been done by an offsite contractor licensed by the State of Washington. Since March of 1972, the shipyard has not intentionally discharged any radioactive liquids to the harbor and has not requested permission to do so.

Although none of the original discharge permits (or any other detailed records) remain for discharges prior to 1972, each year from 1965 through 1972 the data concerning volume and total radioactivity from the discharge permits were summed and the values reported annually to NNPP headquarters by the shipyard. These values are shown in Table 5-1. The discharge shown for 1963 was by an operating nuclear-powered submarine which visited the shipyard, but was not worked on by the shipyard. This submarine was moored on the east side of Pier 6 near the north end. Primary discharge locations for shipyard processed liquid radioactive waste in approximate decreasing order of volume discharged were: adjacent to Drydock 2; west side of Pier 6; adjacent to Drydock 6; adjacent to Drydock 5; adjacent to Drydock 1; and the south end of Pier 6 (Building 839). NNPP work was not performed in Drydocks 3 or 4 during the period discharges were allowed.

As shown in Table 5-1, the highest annual activity discharged at PSNS was 0.02 curie in 1963, which is less than the naturally occurring radioactivity in a cube of sea water 50 yards on a side (Reference 12). For the entire NNPP, annual discharges within 12 miles of land prior to 1973 ranged from 1 to 10 curies; total NNPP discharges (including at sea) have been 0.4 Ci/yr since about 1975 (less than 0.002 curie within 12 miles of land). Compared to the discharges from other nuclear programs and activities and to the millions of curies occurring naturally in the oceans, even the pre-1973 amount of radioactivity is small. Table 5-2 shows 1990 radioactivity discharges from commercial nuclear power plants, in comparison to the NNPP total within 12 miles of land. (Table 5-2 includes all radionuclides with a half-life of greater than 8 days.)

From 1973 through 1993, the shipyard reported total annual discharges (i.e., inadvertent discharges to the harbor) of less than 1000 gallons and less than 0.001 curie (except for 1981 which was 2400 gallons and less than 0.001 curie). This volume primarily originates from disconnecting underwater joints between shipyard collection facilities and nuclear submarines. These lines are blown down prior to disconnection, but some residual water remains at low points in hard piping. Since the disconnection is made by divers, there is no way to measure the amount of water residual in the hard piping connected to the ship. The 1000 gallons is a very conservative volume. In most years, the volume actually released is much less than 1000 gallons. The "less than 0.001 curie" reported is based on a total discharge of 1000 gallons, and is also very conservative.

These volumes do not include rare spills of controlled pure water, due to the very low levels of activity in such water as discussed above. These spills did not affect the "less than 0.001 curie" reported.

Table 5-1
Radioactive Liquid Waste Released to Sinclair Inlet
From Puget Sound Naval Shipyard Due to NNPP Operations
1963-1993

Year	Volume (Thousand Gallons)	Activity (Curies)	Potential Tritium Released (Curies)
1993	< 1	< 0.001	<0.008
1992	< 1	< 0.001	<0.008
1991	< 1	< 0.001	<0.008
1990	< 1	< 0.001	<0.008
1989	< 1	< 0.001	<0.008
1988	< 1	< 0.001	<0.008
1987	< 1	< 0.001	<0.008
1986	< 1	< 0.001	<0.008
1985	< 1	< 0.001	<0.008
1984	< 1	< 0.001	<0.008
1983	< 1	< 0.001	<0.008
1982	< 1	< 0.001	<0.008
1981	2.4	< 0.001	0.018
1980	< 1	< 0.001	<0.008
1979	< 1	< 0.001	<0.008
1978	< 1	< 0.001	<0.008
1977	< 1	< 0.001	<0.008
1976	< 1	< 0.001	<0.008
1975	< 1	< 0.001	<0.008
1974	< 1	< 0.001	<0.008
1973	< 1	< 0.001	<0.008
1972	16	< 0.001	0.16
1971	98	< 0.001	0.74
1970	136	< 0.001	1.0
1969	152	0.001	1.2
1968	182	0.001	1.4
1967	246	0.002	1.9
1966	54	< 0.001	0.41
1965	196	0.006	1.5
1964	< 1	< 0.001	<0.008
1963	1	0.02	0.008

Notes:

1. Includes inadvertent releases. Activity is reported as cobalt-60 equivalent. Refer to Section 2.3 for a discussion of counting terminology. Carbon-14 is excluded. Potential tritium released values assume 0.002 $\mu\text{Ci/ml}$ tritium (effectively a worst case estimate for reactor coolant). Years with largest discharge volumes include anticontamination clothing laundry waste which was a significant portion of the volume, but which contained no tritium, thus making the tritium estimates highly inflated for those years. For comparison, a typical commercial nuclear reactor plant releases several hundred curies of tritium in liquid effluents every year.
2. The discharge shown for 1963 was by an operating nuclear-powered submarine which visited the shipyard, but was not worked on by the shipyard.
3. Planned discharges were discontinued in 1972. Table includes all unplanned discharges listed in Table 5-4.
4. The discharge volume for 1981 involved pumping about 200 gallons of cleaning water from a normally uncontaminated ship's tank to two floating waste oil recovery rafts. Before it was known that the ship's tank and the discharge piping system had become contaminated, about 2400 gallons of water had been discharged into the harbor from the rafts.

Table 5-2
ENVIRONMENTAL RELEASES (Curies)
ON LAND OR WITHIN TERRITORIAL WATERS
Naval¹ vs. Civilian² Reactors

AIRBORNE		LIQUID (less tritium)	
PEACH BOTTOM 2 & 3	11200	MILLSTONE 2	8.76
OCONEE 1, 2 & 3	8840	SOUTH TEXAS 1	7.09
CRYSTAL RIVER 3	7310	SOUTH TEXAS 2	5.72
SEQUOYAH 1 & 2	6070	SURRY 1 & 2	4.50
WATERFORD 3	5730	SALEM 2	3.14
BIG ROCK POINT 1	5660	OCONEE 1, 2 & 3	3.11
VERMONT YANKEE 1	5070	SALEM 1	3.00
MONTICELLO	2960	DIABLO CANYON 1 & 2	2.80
MILLSTONE 2	2890	HADDAM NECK	2.69
INDIAN POINT 1 & 2	2230	ZION 1	2.66
SAN ONOFRE 1	1800	BEAVER VALLEY 1 & 2	2.56
HADDAM NECK	1460	MILLSTONE 3	2.47
BRAIDWOOD 1	1420	ARKANSAS ONE 1	2.36
JAMES A. FITZPATRICK	1350	BRAIDWOOD 1	2.13
BYRON 1 & 2	1240	BRAIDWOOD 2	2.13
PALO VERDE 3	1200	COOPER	2.04
SAN ONOFRE 2 & 3	1160	MCGUIRE 1	2.00
BRUNSWICK 1 & 2	1120	MCGUIRE 2	2.00
EDWIN I. HATCH 1 & 2	1100	DONALD C. COOK 1 & 2	1.61
DAVIS - BESSE 1	1090	HOPE CREEK 1	1.49
RIVER BEND 1	1030	CALVERT CLIFFS 1 & 2	1.42
BRAIDWOOD 2	1020	SEQUOYAH 1 & 2	1.22
WOLF CREEK 1	999	BYRON 1 & 2	1.18
NORTH ANNA 1 & 2	962	INDIAN POINT 1 & 2	1.06
MAINE YANKEE	946	VOGTLE 1 & 2	1.01
FILGRIM 1	907	CATAWBA 1	0.978
COMANCHE PEAK 1	906	CATAWBA 2	0.978
CALLAWAY 1	902	ZION 2	0.926
WNF - 2	890	ST. LUCIE 1	0.827
HOPE CREEK 1	830	FORT CALHOUN 1	0.806
SUMMER 1	761	ST. LUCIE 2	0.768
OYSTER CREEK 1	735	RIVER BEND 1	0.737
PALO VERDE 1	708	HARRIS 1	0.731
ARKANSAS ONE 1	700	WATERFORD 3	0.730
TURKEY POINT 3	688	DRESDEN 1, 2 & 3	0.712
LASALLE 1 & 2	687	NORTH ANNA 1 & 2	0.676
PALO VERDE 2	676	GRAND GULF 1	0.646
CALVERT CLIFFS 1 & 2	672	CRYSTAL RIVER 3	0.619
THREE MILE ISLAND 1	666	FERRY 1	0.610
INDIAN POINT 3	626	BRUNSWICK 1 & 2	0.487
ST. LUCIE 1	619	SAN ONOFRE 1	0.403
HARRIS 1	606	H. B. ROBINSON 2	0.360
R. E. GINNA	595	SUMMER 1	0.366
TURKEY POINT 4	592	LIMERICK 1 & 2	0.343
ST. LUCIE 2	534	WOLF CREEK 1	0.315
CATAWBA 1	533	INDIAN POINT 3	0.309
CATAWBA 2	533	BROWNS FERRY 1, 2 & 3	0.302
MCGUIRE 1	518	EDWIN I. HATCH 1 & 2	0.301
MCGUIRE 2	518	ARKANSAS ONE 2	0.262
FORT CALHOUN 1	469	FERMI 2	0.218
SURRY 1 & 2	461	KEWAUNEE	0.206
SALEM 1	313	SAN ONOFRE 2 & 3	0.202
MILLSTONE 3	211	MAINE YANKEE	0.187
TROJAN	206	R. E. GINNA	0.160
ARKANSAS ONE 2	189	TROJAN	0.144
DONALD C. COOK 1 & 2	188	DAVIS - BESSE 1	0.141
VOGTLE 1 & 2	188	TURKEY POINT 3	0.141
COOPER	187	TURKEY POINT 4	0.140
SOUTH TEXAS 1	172	MILLSTONE 1	0.139
NINE MILE POINT 2	163	SUSQUEHANNA 1 & 2	0.134
FERMI 2	161	PRAIRIE ISLAND 1 & 2	0.130
SALEM 2	149	QUAD - CITIES 1 & 2	0.113
GRAND GULF 1	136	JOSEPH M. FARLEY 2	0.083
PALISADES	121	JOSEPH M. FARLEY 1	0.075
MILLSTONE 1	117	LACROSSE	0.069
YANKEE ROWE 1	113	NINE MILE POINT 2	0.063
ZION 1 & 2	110	CALLAWAY 1	0.039
SOUTH TEXAS 2	109	BIG ROCK POINT 1	0.036
SEABROOK 1	107	JAMES A. FITZPATRICK	0.027
JOSEPH M. FARLEY 1	87	CLINTON 1	0.025
FERRY 1	84	LASALLE 1 & 2	0.025
PRAIRIE ISLAND 1 & 2	83	THREE MILE ISLAND 1	0.024
BEAVER VALLEY 1 & 2	82	FILGRIM 1	0.016
QUAD - CITIES 1 & 2	80	WNF - 2	0.015
SUSQUEHANNA 1 & 2	72	PEACH BOTTOM 2 & 3	0.014
DIABLO CANYON 1 & 2	56	COMANCHE PEAK 1	0.012
DUANE ARNOLD	46	POINT BEACH 1 & 2	0.012
JOSEPH M. FARLEY 2	34	PALISADES	0.008
LIMERICK 1 & 2	34	HUMBOLDT BAY 3	0.006
DRESDEN 2 & 3	20	YANKEE ROWE 1	0.004
CLINTON 1	11	SEABROOK 1	0.002
POINT BEACH 1 & 2	8	NINE MILE POINT 1	0.00196
H. B. ROBINSON 2	7	RANCHO SECO 1	0.00021
KEWAUNEE	2	THREE MILE ISLAND 2	0.00018
RANCHO SECO 1	0.2	FORT ST. VRAIN	0.00008
BROWNS FERRY 1, 2 & 3	N/D	OYSTER CREEK 1	0.00007
DRESDEN 1	N/D	DUANE ARNOLD	N/D
FORT ST. VRAIN	N/D	MONTICELLO	N/D
HUMBOLDT BAY 3	N/D	PALO VERDE 1	N/D
LACROSSE	N/D	PALO VERDE 2	N/D
NINE MILE POINT 1	N/D	PALO VERDE 3	N/D
SHOREHAM 1	N/D	SHOREHAM 1	N/D
THREE MILE ISLAND 2	N/D	VERMONT YANKEE 1	N/D

← NAVAL
 REACTORS
 <50

← NAVAL
 REACTORS
 <0.002

1. Naval reactors include 4 land based prototypes and over 120 ships. Total Program releases are comparable to commercial reactor releases listed above.

2. Source: U. S. Nuclear Regulatory Commission report NUREG/CR - 2907, Vol. 11, October 1993

5.1.2 Air Exhausted From Radiological Facilities

Since nuclear work began at the shipyard, radiological work facility exhaust systems have been equipped with High Efficiency Particulate Air (HEPA) filters and have been monitored for radioactivity.

Beginning in May 1970, the shipyard has documented the results of monitoring air exhausted from radiological work facilities. From May 1970 until May 1973, a fixed-filter continuous air particulate detector was installed to detect air at concentrations of 1×10^{-9} $\mu\text{Ci/ml}$, the regulatory limit for occupational exposure. A similar unit was installed adjacent to the shipyard branch clinic to obtain a background radioactivity level for comparative purposes.

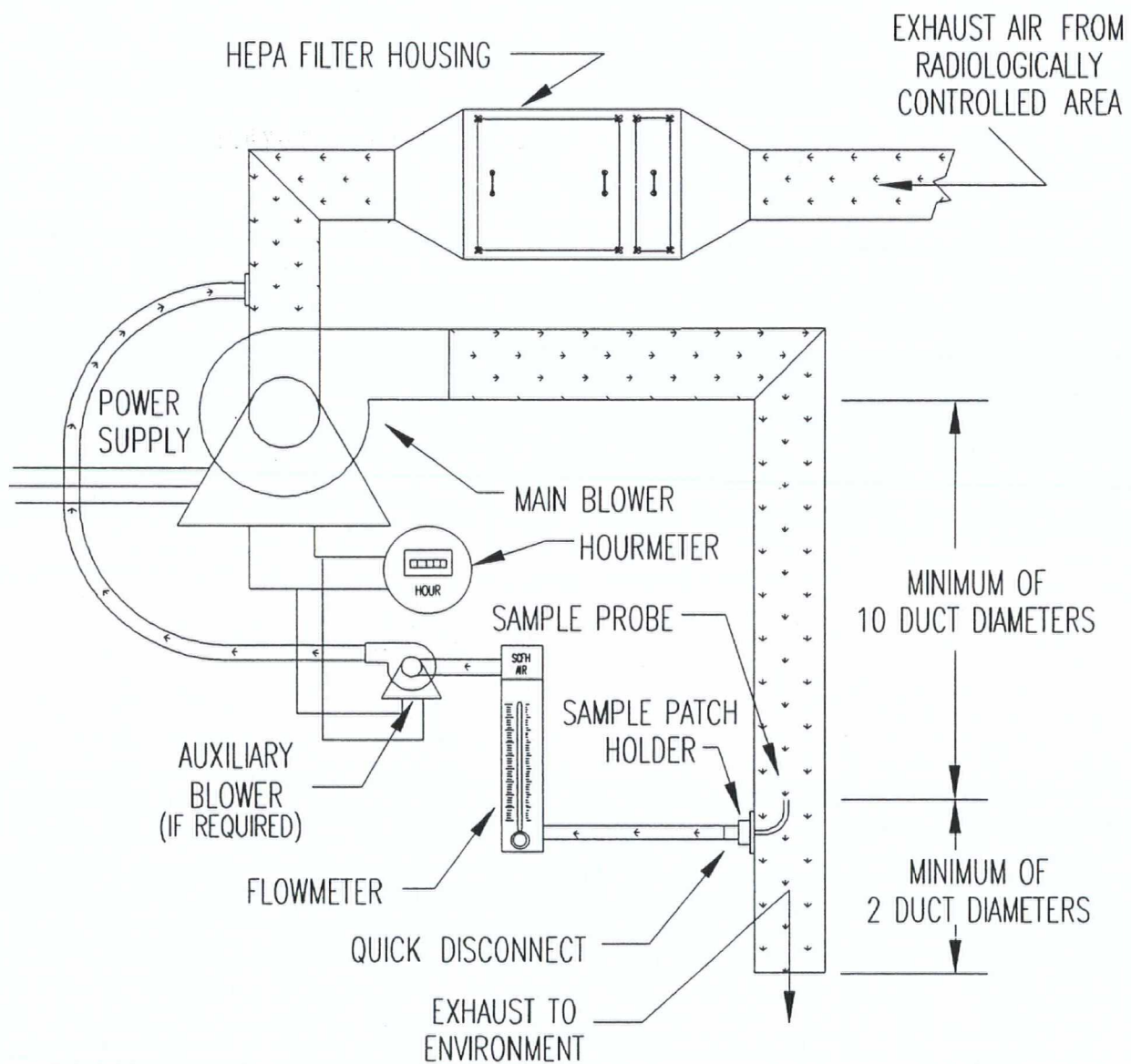
The NNPP soon decided this was not sufficiently sensitive for air exhaust analyses. In May 1973, an Environmental Monitoring System consisting of a vacuum pump, filter holder, differential pressure gauges, totalizing hourmeter, and connecting tubing was installed at each HEPA filter exhausted to the environment. A simplified diagram of this system is shown in Figure 5-2. At the same time, the analysis procedure was revised to require a minimum detectable activity (MDA) of less than 2×10^{-14} $\mu\text{Ci/ml}$. Actual MDAs have generally been lower than this, and most analysis results are "less than MDA." The background sampler was also updated and moved to a location outside the Controlled Industrial Area in the southwest part of the shipyard (upwind for the prevailing wind direction). The low exhaust air radioactivity concentrations shown in Table 5-3 are expected to have existed since the beginning of NNPP work, since HEPA filtering policies have not been changed.

Sampling probe location for the 1973 procedure was determined by obtaining a velocity profile across the duct. A uniform velocity distribution indicates turbulent flow, assuring adequate mixing and entrainment of particulates to permit single point sampling. If the velocity profile did not permit single point sampling (laminar flow), an array of sampling probes could be located in accordance with ANSI N13.1-69. All shipyard systems are configured to permit single point sampling (turbulent flow).

The sampling probe inlet velocity is adjusted to provide isokinetic flow. This assures that a representative sample will be obtained.

The systems are checked weekly to verify the flow rate is within specification and the differential pressure across the filter is within prescribed limits. At a minimum, the sampling filter patch must be changed annually. In practice, much more frequent changes are required due to dust loading of the patch.

Figure 5-2
Simplified Diagram of Environmental
Monitoring System



In 1981, as a cross-check of shipyard analysis results, an independent Department of Energy (DOE) Laboratory began sending the shipyard a simulated Environmental Monitoring System air patch for comparison of laboratory analysis results. Shipyard analysis results have been consistent with DOE laboratory results, as shown in Table 6-3.

Table 5-3 summarizes the results of air exhaust monitoring. Except for 1984 (discussed in Note 2 of Table 5-3), in each year the activity of air exhausted from radiological facilities has contained less total radioactivity than the naturally occurring radioactivity in an equal amount of air from the environment (this is because HEPA filters also remove natural radioactivity, such as radon daughter products).

Table 5-3
**Airborne Particulate Radioactivity in Air Exhausted From
Radiological Facilities vs. Background Radioactivity in Air
Puget Sound Naval Shipyard**

Year	Average Facility Exhaust Air Activity Concentration $\mu\text{Ci/ml}$	Total Airborne Radioactivity Discharged From Facilities $\mu\text{Ci/yr}$	Background Air Activity Concentration $\mu\text{Ci/ml}$	Total Activity If Background Air Had Been Discharged $\mu\text{Ci/yr}$
1993	1.3×10^{-15}	0.6	1.4×10^{-14}	6.7
1992	2.5×10^{-15}	2.0	1.3×10^{-14}	10.3
1991	2.2×10^{-15}	1.3	1.4×10^{-14}	8.1
1990	1.6×10^{-15}	1.0	1.2×10^{-14}	7.2
1989	2.0×10^{-15}	1.3	1.8×10^{-14}	11.5
1988	1.9×10^{-15}	0.8	1.4×10^{-14}	5.9
1987	7.9×10^{-15}	1.4	1.1×10^{-14}	4.5
1986	3.2×10^{-15}	1.2	1.9×10^{-14}	7.1
1985	2.6×10^{-15}	1.5	9.7×10^{-15}	4.2
1984	2.4×10^{-14}	9.4	1.2×10^{-14}	5.2
1983	8.0×10^{-15}	2.9	1.5×10^{-14}	5.4
1982	4.1×10^{-15}	1.6	2.0×10^{-14}	7.6
1981	3.7×10^{-14}	43.7	1.3×10^{-13}	150.5
1980	1.3×10^{-14}	6.8	3.7×10^{-14}	19.5
1979	1.5×10^{-14}	6.7	2.7×10^{-14}	12.1
1978	1.2×10^{-14}	1.85	9.5×10^{-14}	15.2
1977	1.8×10^{-14}	2.4	1.4×10^{-13}	18.3
1976	2.8×10^{-14}	4.6	6.4×10^{-14}	10.6
1975	1.0×10^{-15}	0.3	5.9×10^{-14}	15.3
1974	9.0×10^{-15}	3.6	6.9×10^{-14}	26.4

Notes:

1. Exhaust air activity monitoring began in 1966 based on results of installed air particle detectors. Numerical data was not reported until 1974. HEPA filtering procedures were identical in earlier years, so exhaust air radioactivity levels are expected to have been about the same prior to 1974. Actual exhaust air concentrations are expected to have been lower than reported here, since most analysis results were below detectability and MDA values were included in each year's average for "less than MDA" results.
2. In 1984 the reported total activity released from facilities was greater than the total activity if background air had been discharged because of an unanticipated situation involving a ship's ventilation system. The shipyard was utilizing and monitoring a ship's unfiltered exhaust ventilation system. When higher than anticipated activity levels were detected; actions were taken to eliminate the problem. The highest airborne radioactivity concentration from this monitoring was approximately 500 times lower than the Maximum Permissible Concentration in air (MPCA) for continuous exposure to the general public (10 CFR 20).

These data verify that shipyard air exhausts are about one to two orders of magnitude cleaner than the air in the environment, from a radiological perspective.

EPA regulations for radionuclide emissions from non-DOE Federal facilities, including from Navy Facilities, are contained in Title 40, Code of Federal Regulations, Part 61 (40 CFR 61) Subpart I. The 40 CFR 61 regulations specify more complex radionuclide emissions measurement systems than the NNPP requires for radiological work.

Since 1991, the NNPP and the EPA have been working together to reach agreement on alternate measurement procedures for NNPP work. In 1993, the NNPP submitted a draft agreement to the EPA and formally applied for EPA approval, on an interim basis, for alternate procedures for the measurement and estimation of radionuclide emissions. The agreement called for a two year interim period during which a series of special testing will be performed. These tests will provide additional data on airborne radionuclide releases and are intended to provide the EPA with sufficient information to approve the simplified alternate procedures on a permanent basis. In February 1994, the EPA granted interim approval of alternate procedures for estimation of radionuclide emissions.

One aspect of the interim agreement with the EPA concerns consistency of shipyard exhaust monitoring systems with the American National Standards Institute (ANSI) standard invoked by the EPA regulations. Some of the special tests in the two year test program are intended to quantify the difference, if any, between shipyard sampling systems and ANSI standard sampling systems and determine whether it is necessary to install ANSI standard sampling systems in shipyard exhausts.

As part of the 40 CFR 61 regulations, activities are required to report emissions unless the amounts released are less than 10 percent of the standards. To assist activities in assessing their facilities, the EPA has provided a computer code called COMPLY. The shipyard has run this program using site-specific parameters required for Level 4 analysis using COMPLY. For 1993, the most recent analysis, the COMPLY results are less than 10 percent of the standards, and the shipyard is exempt from the requirements for reporting in accordance with 40 CFR 61.

PSNS notes the NESHAP 40 CFR 61 calculations demonstrate an exposure level to the general public of less than 1.0 mrem/yr, including the contributions from trace levels of fission product gases and gaseous carbon-14 products as discussed in Sections 4.2 and 4.2.3. Noble gasses such as isotopes of argon, krypton, or xenon do not accumulate in the environment and are therefore not a potential candidate for site remediation. Also, even if radioiodines had ever been released in significant quantities (which they haven't been), they would not constitute a potential remediation issue due to their short half lives. Finally, carbon-14 does not accumulate in the environment, as discussed in Section 4.2.3.

5.1.3 Reports of Inadvertent Releases

Naval Nuclear Propulsion Program regulations require that formal reports be submitted to headquarters by activities when inadvertent releases of radioactivity to uncontrolled areas, to personnel, or to the environment occur. These "incident reports" have been required since the inception of the Program. Puget Sound Naval Shipyard has maintained a file of these reports dating back to 1963 (pre-1965 reports relate to training only). Records of each discharge of radioactive water to the harbor are also kept. In addition, environmental monitoring files include reports of special monitoring associated with possible releases to the environment.

An extensive search of discharge records, environmental monitoring reports, and archive copies of incident reports was conducted. A total of eighty-nine (89) instances of known or potential releases of radioactivity to the environment were found; thirty-five (35) of these were incident reports. A comprehensive review of all available detailed records was performed for this HRA. Table 5-4 summarizes data obtained during these reviews. These reviews verified that the affected areas were surveyed and sampled as required by regulations and that the areas were properly released from radiological controls. The release criteria for surface contamination are less than 450 pCi/100 cm² by swipe analysis as discussed in Section 4.4, and less than 450 pCi per 20 cm² scanning probe. The release criteria for soil/concrete at a spill site was formerly less than 30 pCi/g gross gamma, cobalt-60 equivalent; several years ago it was reduced to less than 1 pCi/g cobalt-60 unless NNPP headquarters approves otherwise on a case basis. No such exceptions apply at PSNS. Using NNPP sampling and analysis procedures, these surface and soil release criteria are at the limit of detectability above background.

The review of past incident reports also verified that any radioactive liquids lost to the environment were accounted for and included in the annual discharge reports to the Naval Nuclear Propulsion Program.

That no significant radioactivity was left on the ground as a result of past releases, documented or otherwise, is confirmed by the results of aerial monitoring conducted by EG & G and discussed elsewhere in this HRA. No NNPP radioactivity has ever been detected in harbor water or marine biota samples at PSNS. That no significant radioactivity has accumulated in the marine environment is confirmed by sediment sample results and by storm drain and drydock survey results reported elsewhere in this HRA.

Table 5-4
**Summary of Reports of Potential NNPP
Radioactivity Releases To The Environment**

Date	Location	Volume	Activity
12/69	Mooring adjacent to SW corner of Drydock #2	NA	1.22×10^{-6} μ Ci/ml
Summary: A leak was discovered in a barge's heat exchanger.			
Response: Twelve special harbor sediment samples were taken in the immediate vicinity of the barge's mooring location. No increase in environmental radioactivity was found. The heat exchanger was repaired.			

Date	Location	Volume	Activity
8/4/71	Drydock #1	< 1 gallon	0.01 μ Ci
Summary: A section of hose previously used to transfer radioactive liquid leaked from one end during removal from the drydock. Water dripped onto the drydock floor and the area on the west side of the drydock. This leakage was noticed as it happened and the two areas were controlled immediately.			
Response: The leakage was controlled with a plastic bag and absorbent material. Decontamination was accomplished with strippable latex paint and removal of a small amount of concrete until no detectable radioactivity remained.			

Date	Location	Volume	Activity
1/12/72	Drydock #5	NA	NA
Summary: Small spill of low-level radioactive liquid in the drydock from a leaking inlet fitting on a radioactive liquid collection tank.			
Response: The affected 3 ft by 9 ft area was controlled and cleaned up using strippable latex paint and by subsequent removal of concrete until no detectable radioactivity remained.			

Date	Location	Volume	Activity
9/13/72	Pier 3	0.26 gallons	0.002 μ Ci
Summary: Liquid spilled into the harbor during disconnect of a hose from a ship.			
Response: No action was considered necessary because of the small volume and low level of radioactivity.			

Date	Location	Volume	Activity
11/13/73	Drydock #2	2 gallons	0.1 μ Ci
Summary: Water leaked from a radiologically controlled ventilation system during disassembly.			
Response: The spill area was controlled immediately. Absorbent material was used to soak up the spilled liquid. The highest sample of concrete from the area was 7.8 pCi/g in 1973 (would be 0.5 pCi/g by 1994). The area was released from radiological control.			

Date	Location	Volume	Activity
4/1/74	South of Drydock #6	106 gallons	40 μ Ci
Summary: Water from a normally uncontaminated ship's system leaked to a bilge which was being routinely pumped to a waste oil recovery raft. Routine sampling of the bilge water discovered small amounts of radioactivity. The ship's system turned out to be contaminated.			
Response: The contents of the waste oil recovery raft were controlled. 1750 gallons of oil were released to the Manchester oil recycling facility. 26,000 gallons of water was processed through sand filters to remove low level radioactivity. The sand and sludge remaining in the waste oil recovery raft were disposed of as radioactive waste. Monitoring of the waste oil recovery raft determined that it did not require radiological controls. The recorded release to the environment is a "worst case" estimate. Environmental sampling in the area found no detectable cobalt-60.			

Date	Location	Volume	Activity
11/8/74	Drydock #5	1 gallon	1.5 μ Ci
Summary: Radioactive liquid was spilled onto the drydock floor. About a 10 square foot area became contaminated. No liquid went into the drydock drain system.			
Response: The spillage was absorbed and disposed of as solid radioactive waste. The area was decontaminated with strippable latex.			

Table 5-4 (con't)

Date	Location	Volume	Activity
12/23/74	NA (probably Pier 6)	0.06 gallons	0.037 μ Ci
Summary: Water leaked from a radioactive water transfer hose when a blank flange was removed. Some of the water leaked to the harbor.			
Response: A water sample from the harbor found no detectable radioactivity.			

Date	Location	Volume	Activity
3/14/75	Pier 3 east side	200 gallons	24 μ Ci
Summary: A ship inadvertently pumped bilge water containing low levels of radioactivity to a floating waste oil recovery raft.			
Response: The openings on the bottom of the raft were covered over and water samples were taken from inside and outside the raft. These samples indicated the radioactivity remained in the upper part of the raft, so very little release to the harbor is likely to have occurred. Harbor sediment samples from the vicinity of the raft had radioactivity concentrations consistent with routine environmental monitoring samples with no detectable cobalt-60. The highest radioactivity concentration found in the raft was 3.1×10^{-7} μ Ci/ml. Since this was well below the allowed level for drinking water, and since the liquid was not fit for human consumption due to oil and salt content, it was allowed to be processed in the normal manner in the oil recovery facility, i.e., resulting in the water being released to the harbor and the oil being reclaimed and ultimately burned as fuel. It was conservatively estimated that no more than 200 gallons containing 24 μ Ci was released to the harbor.			

Date	Location	Volume	Activity
3/17/75	Pier 6 south end, east side	not liquid	0.3 μ Ci.
Summary: The wind blew a plastic protective cover from the bottom of a piece of reactor refueling equipment. The cover and 5 to 6 absorbent towels fell into the harbor. Two towels may have sunk.			
Response: The cover and four white absorbent towels were recovered immediately. One towel was later recovered from the harbor bottom by divers. It was never determined whether a sixth towel was lost. Water and harbor bottom sediment samples detected no evidence of radioactivity increase caused by this event. It was conservatively estimated that no more than 0.3 μ Ci was released to the harbor.			

Date	Location	Volume	Activity
4/13/75	NA	3 drops	6×10^{-5} μ Ci
Summary: A leaking gasket on a ship's valve resulted in a small release to the harbor.			
Response: Since the estimated amount of radioactivity released was so small, no actions were necessary.			

Date	Location	Volume	Activity
3/19/75	NA	300 gallons	0.05 μ Ci
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
5/2/75	NA	150 gallons	0.02 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
8/3/75	NA (probably Pier 6)	400 gallons	0.05 μ Ci
Summary: Controlled pure water was inadvertently released to a ship's bilge which was being routinely pumped to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
9/24/75	NA (probably Pier 6)	1 gallon	0.04 μ Ci
Summary: Air bubbles were noted in the vicinity of an underwater radioactive liquid transfer pipe connection during a proof of flow test. Inspection found the connection to be satisfactory, but an estimate of possible discharge was recorded. The most likely source of the bubbles was from a ballast tank due to a change in ship's trim.			
Response: It was conservatively estimated that no more than 1 gallon containing 0.04 μ Ci was released to the harbor.			

Table 5-4 (con't)

Date	Location	Volume	Activity
10/1/75	NA	1500 gallons	0.17 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
1/22/76	NA	250 gallons	0.02 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
3/16/76	NA	"small quantity"	0.01 μ Ci
Summary: A ship inadvertently released a small amount of radioactive liquid to the harbor.			
Response: NA			

Date	Location	Volume	Activity
8/10/76	NA (probably Pier 6)	0.003 gallons	0.0005 μ Ci
Summary: A small amount of water leaked out when a blank flange was removed from a radioactive liquid transfer pipe being installed on a waterborne submarine.			
Response: NA			

Date	Location	Volume	Activity
6/13/77	Pier 6 south end	475 gallons	0.095 μ Ci
Summary: An improper valve line-up resulted in controlled pure water being released while attempting to recirculate the contents of a tank for sampling. Some of the water went into the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
7/77	controlled area east side of Bldg. 839	NA	NA
Summary: A radiological survey performed to release the area from radiological controls found a small amount of radioactive contamination three to five inches under the asphalt surface. This radioactivity was in an area previously used for radiological work within a controlled area. Apparently residual contamination (below release limits) had been paved over after a previous spill clean-up (contrary to allowed policy), and this was not documented because it occurred in a controlled area.			
Response: Asphalt was removed from a 9 ft by 12 ft area and disposed of as radioactive waste. The area was resurveyed and no radioactivity was detectable. The area was released from radiological controls.			

Date	Location	Volume	Activity
Discovered 7/15/77	Pier 6	NA	78 μ Ci
Summary: A routine radiation survey discovered evidence of radioactivity believed associated with a past spill which appeared to have been spread by rainwater along railroad tracks. The affected area was about 20 ft wide and 120 ft long, starting about 36 feet north of Building 839. The highest radioactivity concentration found was 1970 pCi/g in dirt.			
Response: All material above 15 pCi/g gross gamma (residual would be less than 1.6 pCi/g in 1994) was removed and disposed of as radioactive waste. The total amount of cobalt-60 equivalent radioactivity in the removed material was estimated at 58 μ Ci. The estimated release to the harbor via pier drains was 20 μ Ci based on results of harbor sediment samples. The highest cobalt-60 concentration found in nine special harbor sediment samples was 0.08 pCi/g.			

Date	Location	Volume	Activity
11/4/77 - 11/7/77	south of Drydock #2	145 gallons	0.033 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			

Table 5-4 (con't)

Date	Location	Volume	Activity
12/20/77	Drydock #1 west side	"small amount" not estimated	NA
Summary: A valve on an inlet manifold on a portable radioactive liquid collection tank was discovered to have a small leak. Samples of pavement directly below the leak found up to 160 pCi/g gross gamma.			
Response: The area was controlled while pavement was removed from about one square foot. The highest radioactivity found in additional pavement samples after release of the area from radiological controls was 7 pCi/g gross gamma (would be < 1 pCi/g in 1995).			
Date	Location	Volume	Activity
12/20/77 - 12/21/77	Pier 5 west side	65 gallons	6.0 µCi
Summary: Reactor coolant was unaccounted for.			
Response: A technical evaluation concluded that the unaccounted-for water most likely went to a radioactive liquid collection tank and therefore not to the environment. This is therefore a worst-case estimate of a possible release to the harbor.			
Date	Location	Volume	Activity
5/17/78	Farragut Ave. Storage Area	NA	0.02 µCi
Summary: Radioactivity was detected in the gravel in an area of approximately five feet diameter during a quarterly survey of the fenced storage area.			
Response: Approximately one inch of the gravel was removed and disposed of as radioactive waste. Surveys found no detectable radioactivity after gravel removal.			
Date	Location	Volume	Activity
5/23/78	Drydock #2	about 5 gallons	NA
Summary: An unexpected quantity of water drained from a piping low point thought to be empty. This water overflowed a collection bottle before the drain valve could be closed. Some of this water leaked through the floor of the controlled passageway where the bottle was located.			
Response: The spill area was immediately controlled. Some of the water flowed into a storm drain on the drydock floor. Pumping of the drydock was secured until it was confirmed that no radioactivity had reached the drydock pumping sump. The first phase of decontamination involved use of absorbent material and removal of all loose material from the drydock floor and about 20 feet of the storm drain. Final decontamination for release from control involved removal of concrete from about 300 square feet of the drydock floor and about 12 feet of the internal surfaces of the storm drain. All removed materials were disposed of as radioactive waste.			
Date	Location	Volume	Activity
10/20/78	Pier 6 west side	16.9 gallons	0.01 µCi
Summary: A ship inadvertently discharged radioactive liquid to the harbor.			
Response: NA			
Date	Location	Volume	Activity
1/20/79	Drydock #6	34 gallons	0.17 µCi
Summary: Radioactive liquid leaked to the drydock floor during a proof of flow check due to a ship's valve improperly being open.			
Response: Residual water in the spill area was sampled and found to have a radioactivity concentration of 1.3×10^{-6} µCi/ml. Initial sampling of solid material from the spill area detected a maximum of 31 pCi/g gross gamma (would be less than 5 pCi/g in 1994). Additional sampling of the same location found < 9 pCi/g gross gamma (would be < 1.5 pCi/g in 1994). The area was released from radiological controls.			
Date	Location	Volume	Activity
6/8/79	NA	< 2 gallons	< 0.008 µCi
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			
Date	Location	Volume	Activity
9/18/79	east of Drydock #5	30 gallons	< 0.11 µCi
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Table 5-4 (con't)

Date	Location	Volume	Activity
Discovered 9/20/79	Adjacent to SW corner of Bldg. 839	Unknown	0.5 μ Ci (estimated)
Summary: A routine weekly survey of areas adjacent to Building 839 found radioactivity on the pavement. Additional surveys confirmed radioactivity above 30 pCi/g gross gamma in dirt and asphalt.			
Response: The top layer of pavement was removed from an area of approximately 50 square feet and disposed of as radioactive waste. Resurvey found a maximum of 6 pCi/g gross gamma (would be < 1 pCi/g in 1995).			

Date	Location	Volume	Activity
11/16/79	NA	5 gallons	< 0.012 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/26/79	NA	4 gallons	< 0.015 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor by a ship.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
1/23/80	Drydock #2	0.13 gallons	0.001 μ Ci
Summary: A radioactive water sample was inadvertently disposed of into a sink on a barge in drydock. The sink discharge was to the sewer system.			
Response: NA			

Date	Location	Volume	Activity
3/13/80	Pier 3 east side	2 gallons	< 0.008 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/4/80	Pier 3 east side	10 gallons	< 0.04 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
6/22/80	Pier 3 east side	300 gallons	< 0.07 μ Ci
Summary: Controlled pure water spilled from a portable tank sample valve which was locked shut. The water went to the harbor.			
Response: Evaluation determined that the valve locking device allowed enough movement for the leak to occur. The locking device was redesigned to prevent this movement.			

Date	Location	Volume	Activity
6/24/80	Adjacent to south low-bay door of Bldg. 839	< 1 gallon	< 10 μ Ci
Summary: The south low-bay door of Building 839 was temporarily opened to allow material to be brought into the building while a hydrostatic test of a radioactive liquid transfer hose was in progress. A fitting separated from the end of the hose, releasing radioactive water. Some of this water went outside the building and contaminated an area of about 200 square feet.			
Response: Access to the area was controlled immediately and the contamination was contained. Decontamination required removal of asphalt. The highest remaining contamination when the area was released from radiological controls was 13.7 pCi/g gross gamma (would be < 2 pCi/g in 1995).			

Date	Location	Volume	Activity
2/10/81	Pier 6 west side	NA	NA
Summary: A hull adapter for a radioactive liquid collection hose was dropped to the bottom of the harbor shortly after being removed after use.			
Response: The adapter was retrieved by divers who also collected sediment and water samples during the retrieval. There was no detectable cobalt-60 in these samples.			

Table 5-4 (con't)

Date	Location	Volume	Activity
3/6/81 - 3/11/81	south of Drydock #5	2400 gallons	5.9 μ Ci
Summary: Water from cleaning a ship's tank (about 200 gallons) was pumped to a closed-bottom waste oil recover raft. It was later discovered that the ship's tank had been contaminated with radioactive liquid. Initial recovery actions included isolating the waste oil recovery raft and connecting the ship's discharge piping to a second raft. The recorded discharge was estimated based on the volume of non-radioactive water which was processed through contaminated discharge piping and the rafts prior to discovery and resolution of the problem.			
Response: The contents of one raft were controlled and processed as radioactive liquid (both water and oil). The contents of the other raft were sampled and determined to not require control for radioactivity. The piping system's remaining contents were collected and processed as radioactive liquid. Harbor water and sediment samples found no detectable radioactivity. Recovery involved removal and disposal as radioactive waste of the piping system used to transfer liquid from the ship to the raft, and decontamination of the raft.			
Date	Location	Volume	Activity
6/24/81	Pier 3 east side	2.5 gallons	0.05 μ Ci
Summary: A ship inadvertently released radioactive liquid to the harbor.			
Response: NA			
Date	Location	Volume	Activity
9/23/81	Drydock #2	18 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			
Date	Location	Volume	Activity
12/11/81	Pavement on east side of Building 513	dry spill	none released
Summary: While unloading a shipment of radioactive material from a private company, loose surface contamination was found on the outside. Contamination was found over a 54 ft by 73 ft area.			
Response: The area was immediately controlled. Decontamination was accomplished using strippable latex and removal of some pavement. The removed materials were all disposed of as radioactive waste.			
Date	Location	Volume	Activity
1/14/82	Pier 3 east side	"small amount"	NA
Summary: Momentary inadvertent operation of a ship's valve released a small amount of radioactive liquid to the harbor.			
Response: Water and sediment samples were taken. There was no detectable cobalt-60.			
Date	Location	Volume	Activity
11/28/82	Pier 5 southeast corner	70 gallons	< 0.005 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			
Date	Location	Volume	Activity
10/23/83	Pier 6 east side	10 gallons	< 0.0008 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			
Date	Location	Volume	Activity
8/27/84	Pier 6 west side	25 gallons	< 0.002 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			
Date	Location	Volume	Activity
10/15/84	Pier 6 west side	20 gallons	< 0.002 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Table 5-4 (con't)

Date	Location	Volume	Activity
10/26/84	Pier 6 west side	10 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/12/84	Pier 6 west side	1 gallons	< 0.0001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/24/86	Pier 6 west side	2 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
6/14/86	south of Drydock #5	5 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
9/9/86	Pier 6 west side	3 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
10/22/86	south of Drydock #1	2 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
10/31/86	Pier 6 east side	0.007 gallons	< 0.0001 μCi
Summary: A small amount of radioactive liquid was inadvertently released to the harbor.			
Response: NA			

Date	Location	Volume	Activity
12/19/86	south of Drydock #4	2 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
3/9/87	Pier 6 east side	15 gallons	< 0.002 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/14/87	Pier 6 east side	5 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
6/24/87	south of Drydock #2	6 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Table 5-4 (con't)

Date	Location	Volume	Activity
11/3/87	south of Drydock #2	5 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
11/6/87	south of Drydock #6	1 gallon	< 0.015 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/1/87	south of Drydock #1	7 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/7/87	south of Drydock #2	5 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/12/88	Pier 3 southeast end	3 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
6/6/88	east of Mooring A	5 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to a storm drain that emptied directly to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
11/23/88	Pier 6 west side	5 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/9/88	south of Drydock #2	3 gallons	< 0.001 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
3/18/89	Drydock #4	55 gallons	< 1 μ Ci.
Summary: A ship's valve leaked radioactive liquid to a bilge. Bilge water was being routinely pumped to a 55 gallon drum on the drydock floor. The drum was emptied to a drydock drain before the valve leak was discovered.			
Response: The area where the 55 gallon drum was emptied was monitored for residual radioactivity. Samples from the area had no detectable cobalt-60.			

Date	Location	Volume	Activity
6/4/89	south of Drydock #1	32 gallons	< 0.004 μ Ci
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
9/8/89	Drydock #6 west side on pier	300 gallons	< 0.034 μ Ci
Summary: Controlled pure water spilled due to a leaking pump seal on a portable tank.			
Response: No action required (Note c). Although not required, surveys of the pier were performed and detected no residual radioactivity.			

Table 5-4 (con't)

Date	Location	Volume	Activity
10/12/89	south of Drydock #6	30 gallons	< 0.003 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
12/10/89	south of Drydock #6	10 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
3/15/90	Pier 3 southeast side	11 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/1/90 - 4/5/90	Pier 3 southeast side	50 gallons	0.52 μCi
Summary: Radioactive liquid leaked to a ship's bilge. The bilge was routinely pumped to the harbor before the problem was discovered.			
Response: The leakage was stopped.			

Date	Location	Volume	Activity
4/9/90	southwest side, Drydock #4	43 gallons	< 0.005 μCi
Summary: Controlled pure water was inadvertently released into the drydock from a damaged hose.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/19/90	south end of Drydock #2	240 gallons	< 0.027 μCi
Summary: Controlled pure water spilled to the drydock floor from a damaged hose.			
Response: No action required (Note c). Although not required, surveys detected no residual radioactivity.			

Date	Location	Volume	Activity
7/27/90	Pier 5 southwest end	0.004 gallons	< 0.001 μCi
Summary: A transfer hose connection to a ship leaked to the harbor during a hydrostatic test.			
Response: NA			

Date	Location	Volume	Activity
8/29/90	Drydock #5	5 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
11/16/90	south of Drydock #6	40 gallons	< 0.005 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
11/25/90	Drydock #6	40 gallons	< 0.005 μCi
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
1/12/91	Drydock #6	157 gallons	< 0.018 μCi
Summary: Controlled pure water spilled from a leaking transfer pump.			
Response: No action required (Note c).			

Table 5-4 (con't)

Date	Location	Volume	Activity
1/29/91	Drydock #3	< 0.125 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
2/1/91	Drydock #6	3 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
3/4/91	adjacent to Drydock #6	300 gallons	< 0.035 μCi
Summary: Heat from a steam hose next to a controlled pure water hose caused the controlled pure water hose to rupture. The resultant leakage went to a storm drain.			
Response: Procedures were revised.			

Date	Location	Volume	Activity
3/20/91	south of Drydock #3	0.125 gallons	< 0.002 μCi
Summary: Water leaked from a small hole in a radioactive liquid collection tank as it was being removed from a drydocked submarine. The leakage wetted a keel block and the drydock floor.			
Response: The spill area was immediately controlled. The keel block and small area of the drydock floor were decontaminated by removal of about one-half inch of concrete. Residual cobalt-60 activity was determined to be less than 1 pCi/g.			

Date	Location	Volume	Activity
9/20/91	Pier 6 south end	0.125 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
11/7/92	Pier 3 west side	1.1 gallons	< 0.001 μCi
Summary: Controlled pure water was inadvertently released to the harbor.			
Response: No action required (Note c).			

Date	Location	Volume	Activity
4/6/93	Storm drain #3019 with discharge near Drydock #6	400 gallons	< 0.045 μCi
Summary: Controlled pure water spilled to a storm drain when a fitting on a sight glass came loose.			
Response: No action required (Note c).			

Notes:

- a) NA - data not available or not applicable to the event.
- b) Spills are also assumed to have occurred within controlled radiological work facilities in Buildings 839 and 880. Despite the special design features of such facilities, it is conceivable that some radioactivity remains (e.g., within concrete flooring). These facilities will warrant special sampling and surveying in the event they are to be released from radiological controls.
- c) 54 of 89 items above consist only of spills of controlled pure water; this is reactor cooling water which has been processed to remove virtually all particulate radioactivity (to below 6×10^{-8} $\mu\text{Ci}/\text{ml}$ cobalt-60, see Section 5.1.1.1). For reference purposes, this controlled pure water is well below the Nuclear Regulatory Commission's 10 CFR 20 Appendix B unrestricted release criteria for cobalt-60 and sanitary sewer release criteria for tritium. Nevertheless, the NNPP controls this water.

5.2 Low-Level Solid Radioactive Waste Disposal

5.2.1 Policy

Solid low-level radioactive waste is generated during operation and maintenance of Naval nuclear-powered ships. This low level waste consists primarily of contaminated rags, plastic bags, paper, filters, ion exchange resin, and scrap materials. To maintain accountability, strict controls over these materials are implemented. These controls include serialized tagging and marking, and signatures by radiologically trained personnel to document transfers of materials. Solid radioactive waste materials are packaged in strong tight containers and shielded as necessary.

From the inception of the Program, on-site disposal of radioactive solid waste has been prohibited. This policy was described in early reports such as "Radioactive Waste Disposal from U.S. Naval Nuclear Powered Ships," January 1959, Reference 13. Radioactive solid waste was shipped to disposal sites operated or authorized by the Atomic Energy Commission (AEC). In the early years of the Program, this included some AEC-authorized ocean disposal sites. PSNS has not used ocean disposal. When commercially operated sites licensed by the AEC or a state under agreement with the AEC became available, Navy solid waste was sent to these sites. Currently, such waste is shipped to disposal sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission.

The quantity of solid radioactive waste generated and shipped in any one year from PSNS depends on the amount and type of support work performed that year.

Spent Naval fuel is shipped to Idaho. All other radioactive shipments in the NNPP contain only low-level radioactivity classified under Department of Transportation regulations as low specific activity or limited quantity shipments. The predominant radionuclide associated with these shipments is cobalt-60 in the form of insoluble metallic oxide corrosion products attached to surfaces of materials inside shipping containers. Most low-level shipments are made by truck. Air transport is used no more than a few times per year for the NNPP. These air shipments involve only very low levels of radioactivity and are restricted to cargo aircraft. Radioactive waste is not shipped by air.

The policies and practices used successfully for over 40 years in managing radioactive materials and radioactive waste continue to be used currently. Reference 9 discusses and also illustrates the overall performance of the Program since 1961 in managing radioactive waste.

Facilities continue to be prohibited from disposing of radioactive waste on site. No NNPP sites have active or inactive disposal areas for Program radioactive materials.

Shipyards currently have agreements with Fleet activities in their geographic area to dispose of Fleet radioactive waste. Shipyards have only limited storage areas for staging waste for disposal. The Program policies of minimizing waste at the point of generation and then disposing of it as soon as processing and packaging are completed continue to be applied.

5.2.2 Records

The annual summary of solid waste disposal is included with the annual environmental monitoring reports prepared by the Naval Nuclear Propulsion Program. A synopsis of annual solid radioactive waste data derived from available records is contained in Table 5-5.

All solid radioactive waste listed in Table 5-5 was disposed of at the Hanford, Washington commercial radioactive waste disposal site. Table 5-5 does not include classified components disposed of at the Hanford, Washington DOE site or spent fuel which was sent to the Idaho National Engineering Laboratory (INEL). Also not included are reactor compartment disposal packages sent to the Hanford, Washington DOE site.

The existence of waste disposal records dating back to 1965 and continuing through 1993, along with the prohibition of disposing of waste on-site, provide evidence that no solid radioactive waste has been disposed of on shipyard property. Adding to this evidence are the results of the aerial radiological survey conducted by EG & G and reported in Section 6.7.

Table 5-5
**Summary of Solid Radioactive Waste
Disposal From Puget Sound Naval Shipyard**

Year	Volume Cubic Feet
1993	16,000
1992	23,000
1991	19,244
1990	9,605
1989	7,211
1988	6,316
1987	3,980
1986	5,125
1985	3,872
1984	6,086
1983	5,167
1982	4,098
1981	4,147
1980	4,084
1979	5,928
1978	7,350
1977	6,190
1976	7,561
1975	14,340
1974	19,542
1973	9,777
1972	9,349
1971	20,805
1970	17,349
1969	10,555
1968	13,900
1967	14,100
1966	1,400
1965	400

5.3 Mixed Waste

Mixed waste (waste which is both hazardous and contaminated with low level radioactivity) has been generated during overhaul and repair of nuclear-powered ships. Efforts to minimize the generation of mixed waste have been largely successful, but PSNS has produced small quantities of mixed waste. The mixed waste consists of several specific waste streams containing cloth and plastics with petroleum products, elemental lead, and other smaller volume waste streams mixed with low level radioactive contamination.

Given the lack of national capacity to treat and dispose of mixed waste, it is necessary to store this small amount of mixed waste at the shipyard. Treatment of mixed waste will occur as specified in the Site Treatment Plan, in accordance with a consent order issued by the Washington State Department of Ecology in October 1995. The material will be shipped elsewhere for treatment.

5.4 Release of Facilities and Equipment Previously Used for Radiological Work

NNPP regulations require that activities engaged in Naval nuclear propulsion plant work compile and maintain lists of facilities, areas, and equipment that have been used in support of radiological work. These regulations further require that extensive radiological surveys be conducted when these radiological work or storage areas will no longer be used or when the area, facility, or equipment is being released from radiological control.

Such surveys include those using a gamma scintillation type meter, and beta-gamma frisk surveys. Solid material samples are analyzed for gross cobalt-60 equivalent activity and, where activity exceeds 1 pCi/g, are analyzed with a high-purity germanium detector coupled to a multichannel analyzer. Samples are taken in defined grids. Any radioactivity detected by surveys or samples is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria are discussed in Sections 4.4 and 5.1.3.

Results of surveys and sample analyses are formally documented and archived. For those areas being permanently released, a written report describing the area, radiological history, surveys and sampling protocol, tabulated results, and conclusions is forwarded to NNPP headquarters.

Table 5-6 lists previous radiologically controlled facilities that have been released for unrestricted use.

Table 5-6
**Previous Radiological Facilities Unconditionally
Released From Radiological Controls**

Facility	Radiological Use
Building 513 (south end) (released in 1984)	Radioactive Material Storage
Building 91 (ground floor, west side) (released in 1975) (building demolished in 1985) (location was east side of Drydock 3)	Radiochemistry Laboratory

Pier and wharf areas adjacent to berths where nuclear ships are moored are used to locate portable radioactive liquid waste collection tanks, and occasionally serve as temporary radioactive material storage areas. Radioactive liquid waste tanks are controlled by technical working documents approved by the Radiological Engineering management. Temporary radioactive material storage areas to be used for periods exceeding one week require the written approval of the shipyard's Director of Radiological Control.

When a radioactive liquid waste tank is relocated or a temporary radioactive material storage area is disestablished, beta-gamma radiological surveys are performed prior to removing signs and barriers. The area must meet the Naval Nuclear Propulsion Program limits of less than 450 pCi/100 cm² swipe sample, or less than 450 pCi/20 cm² scanning probe, to be released for general use. Even then, the area is included on the list of those areas requiring permanent release as described above.

Radiological equipment, including portable work and storage enclosures, are maintained under the control of radiological control personnel until permanently released as described above. In addition, if the equipment has any crevices which could trap loose surface contamination, the item must be bulk counted before release or be disposed of as solid radioactive waste.

An example of the large-scale release of prior NNPP radiological facilities occurred when the NNPP left Ingalls Shipbuilding in Pascagoula, Mississippi. From 1958 to 1980, Ingalls Shipbuilding was engaged in the construction and overhaul of Naval nuclear-powered ships. The shipyard radiological facilities which supported this work were deactivated between 1980 and 1982. Extensive radiological decommissioning surveys were performed to verify the effectiveness of deactivation. Direct radiological surveys were performed on over 274,000 square feet of building and facility surfaces. Over 11,000 samples of these surfaces as well as soil, ground cover, and concrete were taken from all areas where radioactive work was previously performed. These samples were analyzed using sensitive laboratory equipment. In addition, both the State of Mississippi and the Environmental Protection Agency (Reference 14) performed overcheck surveys of the deactivated facilities. After these surveys were completed, the Ingalls facilities were released for unrestricted use. Personnel who subsequently occupy these facilities will not receive detectable radiation exposure above natural background levels. This relatively rapid and inexpensive remediation effort was only possible due to the NNPP policy of operating its radiological facilities in a manner which does not impact the environment.

5.5 Current Radiological Facilities

Other than active radiological work and storage areas, there are no areas within the shipyard where radioactivity exists above NNPP limits. Current NNPP radiological work and storage areas are identified in Table 5-7.

Table 5-7
Radiological Work and Storage Areas Currently in Use

Facility ^(a)	Radiological Use
Tunnel #4 (since about 1963)	Radioactive Material Storage
Building 368 (south end) (since 1984)	Radioactive Material Storage
Building 368 (north) (since 1991)	Radioactive Material Storage (mixed waste)
Farragut Avenue Storage Area (north of Bldg. 368) (since about 1969)	Radioactive Material Storage
Portable Tank Storage Area (east of Bldg. 368) (since about 1968)	Radioactive Material Storage
Fenced Area West of Building 447 (since 1990)	Radioactive Material Storage
Fenced Area West of Drydock #3 (since June 1993)	Radioactive Material Storage
Fenced Area on Pier 7 (since 1990)	Radioactive Material Storage
Building 839 (since 1965)	Radiological Work Facility
Building 856 (partial) (since 1973)	Refueling Equipment Storage and Maintenance
Building 880 (water pit facility) (since 1984)	Radiological Work Facility
Piers 3, 4, 5, and 6 (since about 1967) ^(b)	In-Transit Radioactive Material Storage
Drydocks 1, 2, 3, 4, 5, and 6 (since about 1967) ^(b)	In-Transit Radioactive Material Storage

Notes: (a) Dates of first use are in parenthesis and specified to the degree of accuracy available in records.

(b) Specific designation of in-transit radioactive material storage areas occurred in July 1993. Radioactive materials had been transported through these areas beginning in about 1967 when the first work involving significant amounts of radioactive materials began. In-transit radioactive materials are present in these areas for short periods of time and are packaged to preclude release of radioactive contamination to the environment.

6.0 Environmental Monitoring Program

Radiological environmental monitoring has been conducted at PSNS since the beginning of its involvement with Naval nuclear-powered ships. This monitoring consists of analyzing harbor sediment, water, and marine life samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities, and related monitoring. The scope and analysis methods of PSNS monitoring are sensitive enough to identify environmental radioactivity from various sources, such as that due to airborne nuclear tests in past years. Environmental samples are also checked at least annually by a U.S. Department of Energy laboratory to ensure analytical procedures are correct and standardized within the NNPP.

The NNPP environmental monitoring program does not include monitoring within the air, soil, or ground water pathways. The procedures discussed in prior sections to control radioactivity at the source during work, as substantiated by NESHAPS calculations, document that air releases are below the level of environmental significance. The NNPP policy for spills, including immediate containment and corrective action as soon as they are identified, precludes the likelihood for soil or ground water contamination. PSNS notes that, as discussed previously, there is very little exposed soil within the industrial area, and shallow ground water drains directly to the harbor without impacting drinking water wells. For these reasons, the lack of direct air, soil, or ground water monitoring within the shipyard's routine environmental monitoring program is acceptable.

Sections 2.3.1 and 4.2.1 discuss the basis for cobalt-60 being the primary radionuclide of interest for the NNPP.

6.1 Harbor Environmental Records

Harbor environmental data consisting of sediment, water, and marine life sample analysis data are applicable to the surface water pathway.

6.1.1 Sediment Sampling

Initial sediment samples were taken in 1963 as part of a base-line study prior to beginning NNPP work.

The earliest published report that included sediment sampling data is contained in Reference 15. Table II of Reference 15 shows that in 1966, 140 samples were taken at the shipyard. All samples were less than 10 pCi/cm². Two samples per quarterly sampling period were sent to the U.S. Public Health Service Southeastern Radiological Health Laboratory for independent analysis. As an additional intercomparison, some randomly selected samples were sent to a U.S. Atomic Energy Commission laboratory for analysis.

In 1966, PSNS implemented a uniform Program environmental monitoring protocol. Sediment samples have been collected quarterly through the present.

Beginning in 1967, the NNPP has published an annual report of environmental monitoring and waste disposal throughout the Program. These reports have been made available to federal

regulatory agencies, state governments, and the general public. Reference 9 is the latest in this series of reports.

Each of the annual reports contains sediment sampling data. Data for sediment sampling results reported annually by Puget Sound Naval Shipyard are included in Table 6-1.

Table 6-1
Average Gross Beta Activity in Harbor Sediment Samples
Puget Sound Naval Shipyard
1963 and 1964

Year	Quarter	Average Gross Beta Activity, pCi/g						
		Weekly Sample Location						
		Mooring F South (a)	Pier 6 South	Pier 8 South	Pier 6 NE	Mooring G South (a)	Pier 6 NW	Pier 4 NE
1963(b)	1	116	67	67				
	2	125	97	84				
	3	123	80	82				
	4	94	104	75	85			
1964	1		90.4	87.2		88.3	56.9	
	2		84.2	90.6		95.5	47.7	107.5
	3		95.8	78.6		86.5	55.8	104.5
	4		53.3	48.9		45.8	41.1	43.4

Notes: (a) Control sample. West end of shipyard, away from nuclear ships. Moved from Mooring F to Mooring G because mooring G results were more consistent with those from other monitored locations. All Mooring F samples had been taken prior to arrival of the first nuclear-powered vessel.
(b) The first nuclear vessel (submarine) to visit the shipyard moored at Pier 6 NE in November 1963.

Gross Beta Activity Concentration in Harbor Sediment Samples
Puget Sound Naval Shipyard
1965-1967

Year	Quarter	Number of Samples (a)	Average pCi/g	Range Highest/Lowest pCi/g
1965 (b)	1	65	34	54 - 9.3
	2	64	33	55 - 18
	3	62	30	39 - 20
	4	52	28	34 - 17
1966 (c)	1	35	20.6	NA
	2	35	22.5	NA
	3	35	18.8	NA
	4	35	17.8	NA
1967	1	35	18.2	NA
	2	35	16.3	NA
	3	35	16.0	NA
	4	NA (c)	NA (c)	NA

Notes: (a) Prior to 1966, sample frequency was weekly. In 1966 it was changed to quarterly.
(b) In 1965, except for the fourth quarter when samples were not taken at Pier 4 NE and Pier 5 NW, weekly sampling was performed at Mooring G, Pier 6 South, Pier 8 South, Pier 6 NW, Pier 4 NE, Pier 4 NW, and Pier 5 NW.
(c) Gross gamma analysis started in 1966. Gross beta analysis continued as a secondary method until discontinued in the fourth quarter of 1967.

Table 6-1 (con't)

**Gamma Radioactivity Concentration in Harbor Sediment Samples
Puget Sound Naval Shipyard
1966-1970**

Year	Quarter	No. of Samples with Co-60 Energy Range (1.1-1.4 MeV) Activity			Gross Gamma Results, 0.1-2.0 MeV	
		<10 pCi/cm ²	10-100 pCi/cm ²	>100 pCi/cm ²	Average pCi/cm ²	Range: High/Low pCi/cm ²
1966	1	35	0	0	2.4	7.5 - 0.7
	2	35	0	0	2.8	10.9 - 0.7
	3	35	0	0	2.6	5.5 - 0.7
	4	35	0	0	3.6	13.4 - 0.7
1967	1	35	0	0	3.7	14.9 - 0.5
	2	35	0	0	4.0	16.3 - 0.9
	3	35	0	0	1.8	5.3 - 0.5
	4	35	0	0	1.9	10.3 - 0.4
1968	1	35	0	0	2.5	11.5 - 0.3
	2	35	0	0	2.2	5.5 - 0.7
	3	35	0	0	3.4	26.0 - 0.5
	4	35	0	0	2.4	15.2 - 0.5
1969	1	34	0	0	2.5	20.7 - 0.1
	2	35	0	0	2.7	11.5 - 0.2
	3	35	0	0	2.3	14.2 - 0.2
	4	34	0	0	2.8	17.7 - 0.1
1970	1	35	0	0	3.2	24.9 - 0.3
	2	35	0	0	2.3	11.7 - 0.1
	3	35	0	0	1.5	11.9 - <0.1
	4	36	0	0	1.4	6.6 - 0.2

Notes: From 1966 to 1970, the units were pCi/cm². There is no direct conversion from cm² to gram without knowing the number of dredge loads needed to obtain a sample. This was corrected in 1971 by reporting pCi/g.

Table 6-1 (con't)
Gamma Radioactivity Concentration in Harbor Sediment Samples
Puget Sound Naval Shipyard
1971-1993

Year	Quarter	No. of Samples with Co-60 Energy Range (1.1-1.4 MeV) Activity			Gross Gamma Results, 0.1 - 2.1 MeV		Specific Cobalt-60 ^(b)	
		<3 pCi/g	3 - 30 pCi/g	>30 pCi/g	Average pCi/g	Range: High/Low pCi/g	Average pCi/g	High/Low pCi/g
1971	1	36	0	0	0.86	4.51 - <0.12		
	2	36	0	0	0.68	3.95 - 0.25		
	3	36	0	0	0.87	2.90 - 0.36		
	4	42	0	0	0.64	2.60 - 0.27		
1972	1	39	0	0	0.73	4.2 - <0.29		
	2	39	0	0	0.80	4.6 - <0.23		
	3	39	0	0	0.81	4.4 - <0.33		
	4	39	0	0	0.95	6.3 - <0.34		
1973	1	39	0	0	0.91	4.9 - 0.38		
	2	41	0	0	0.68	4.1 - 0.18		
	3	41	0	0	0.86	4.8 - 0.28		
	4	41	0	0	0.63	2.1 - 0.28		
1974	1	41	0	0	0.7	2.4 - 0.3		
	2	41	0	0	0.7	1.9 - <0.4		
	3	41	0	0	0.8	3.7 - 0.3		
	4	41	0	0	0.8	2.6 - <0.2		
1975	1	44	0	0	0.6	1.1 - <0.3		
	2	45	0	0	0.8	3.7 - 0.3		
	3	45	0	0	0.8	5.5 - 0.2		
	4	47	0	0	0.6	5.0 - <0.3		
1976	1	47	0	0	0.6	3.7 - <0.2		
	2	47	0	0	0.7	5.2 - 0.2		
	3	47	0	0	0.7	5.4 - <0.2		
	4	47	0	0	0.7	5.5 - <0.2		
1977	1	47	0	0	0.7	4.9 - <0.2		
	2	47	0	0	0.7	5.7 - <0.3		
	3	47	0	0	0.7	4.1 - 0.2		
	4	47	0	0	0.9	5.3 - 0.3		
1978	1	47	0	0	0.8	6.0 - 0.2	<0.1	<0.13 - <0.02
	2	47	0	0	0.7	5.7 - 0.2		
	3	47	0	0	0.7	6.0 - 0.2		
	4	47	0	0	0.7	5.7 - 0.1		
1979	1	47	0	0	0.8	4.7 - 0.1	<0.01	<0.16 - <0.02
	2	47	0	0	0.6	4.3 - 0.2		
	3	49	0	0	0.7	5.7 - 0.2		
	4	49	0	0	0.6	3.1 - 0.1		
1980	1	49	0	0	0.6	3.5 - 0.1	<0.01	<0.10 - <0.02
	2	49	0	0	0.7	3.8 - 0.1		
	3	49	0	0	0.6	3.4 - 0.1		
	4	49	0	0	0.7	3.2 - 0.1		
1981	1	49	0	0	0.6	2.3 - 0.2	<0.06	<0.12 - <0.02
	2	49	0	0	0.7	4.5 - 0.1		
	3	49	0	0	0.6	4.5 - 0.1		
	4	49	0	0	0.5	2.5 - 0.1		

Table 6-1 (con't)
Gamma Radioactivity Concentration in Harbor Sediment Samples
Puget Sound Naval Shipyard
1971-1993

Year	Quarter	No. of Samples with Co-60 Energy Range (1.1-1.4 MeV) Activity			Gross Gamma Results 0.1-2.1 MeV		Specific Cobalt-60 ^(b)	
		<3 pCi/g	3 - 30 pCi/g	>30 pCi/g	Average pCi/g	High/Low pCi/g	Average pCi/g	High/Low pCi/g
1982	1	49	0	0	0.6	3.9 - 0.1	<0.06	<0.13 - <0.02
	2	49	0	0	0.5	3.6 - 0.1		
	3	52	0	0	0.6	3.2 - 0.1		
	4	52	0	0	0.7	3.6 - 0.1		
1983	1	52	0	0	0.8	3.7 - 0.2	<0.05	<0.08 - <0.02
	2	48	0	0	0.5	1.8 - 0.1		
	3	48	0	0	0.7	3.3 - 0.2		
	4	48	0	0	0.6	2.5 - 0.1		
1984	1	48	0	0	0.6	3.1 - 0.1	<0.04	<0.07 - <0.02
	2	48	0	0	0.6	3.4 - 0.1		
	3	48	0	0	0.5	2.8 - 0.1		
	4	48	0	0	0.5	2.1 - 0.1		
1985	1	48	0	0	0.7	1.5 - 0.2	<0.07	<0.11 - <0.04
	2	48	0	0	0.6	2.3 - 0.3		
	3	48	0	0	0.6	2.6 - 0.4		
	4	48	0	0	0.6	1.8 - 0.3		
1986	1	49	0	0	0.7	1.9 - 0.2	<0.05	<0.10 - <0.02
	2	49	0	0	0.6	1.5 - 0.3		
	3	49	0	0	0.7	2.5 - 0.4		
	4	49	0	0	0.7	1.5 - 0.4		
1987	1	49	0	0	0.6	1.6 - 0.3	<0.06	<0.12 - <0.03
	2	49	0	0	0.7	1.4 - 0.3		
	3	49	0	0	0.6	1.2 - 0.4		
	4	51	0	0	0.7	2.2 - 0.4		
1988	1	52	0	0	0.6	1.7 - 0.4	<0.07	<0.11 - <0.03
	2	52	0	0	0.7	3.9 - 0.4	<0.10	<0.22 - <0.03
	3	52	0	0	0.6	2.1 - 0.3	<0.10	0.32 - <0.03 ^(c)
	4	52	0	0	0.6	1.3 - 0.4	<0.07	<0.13 - <0.04
1989	1	52	0	0	0.6	0.9 - 0.4	<0.07	<0.12 - <0.03
	2	52	0	0	0.6	1.0 - 0.3	<0.07	<0.12 - <0.03
	3	52	0	0	0.5	1.0 - 0.3	<0.06	<0.09 - <0.02
	4	52	0	0	0.5	1.3 - 0.3	<0.07	<0.13 - <0.02
1990	1	52	0	0	0.5	0.9 - 0.3	<0.07	<0.15 - <0.02
	2	52	0	0	0.6	0.9 - 0.4	<0.07	<0.13 - <0.02
	3	52	0	0	0.6	0.9 - 0.2	<0.07	<0.13 - <0.03
	4	52	0	0	0.6	1.1 - 0.4	<0.06	<0.13 - <0.02
1991	1	52	0	0	0.6	1.0 - 0.4	<0.07	<0.11 - <0.02
	2	52	0	0	0.6	1.7 - 0.4	<0.07	<0.13 - <0.02
	3	52	0	0	0.6	1.0 - 0.3	<0.08	<0.14 - <0.03
	4	52	0	0	0.5	1.1 - 0.3	<0.07	<0.12 - <0.02
1992	1	52	0	0	0.5	1.5 - 0.2	<0.06	<0.10 - <0.02
	2	52	0	0	0.6	1.5 - 0.2	<0.06	<0.11 - <0.02
	3	52	0	0	0.5	0.8 - 0.4	<0.05	<0.08 - <0.02
	4	52	0	0	0.6	1.1 - 0.4	<0.06	<0.11 - <0.03
1993	1	52	0	0	0.6	1.5 - 0.2	<0.06	<0.12 - <0.02
	2	52	0	0	0.6	2.2 - 0.3	<0.08	<0.39 - <0.03
	3	52	0	0	0.5	1.0 - 0.3	<0.06	<0.15 - <0.02
	4	52	0	0	0.5	0.9 - 0.2	<0.07	<0.14 - <0.02

Notes: (a) Values preceded by a < symbol are the Minimum Detectable Activity (MDA) for that particular analysis; the sample analysis result was less than MDA. All other values are accurate to the number of significant figures shown.

(b) Specific cobalt-60 data from 1978 through 1987 is from Table 6-2, and includes results from 16 to 22 first quarter samples only.

(c) One sample had cobalt-60 activity above MDA. This sample was taken from the seawall adjacent to Building 529 at the northwest corner of Pier 6. Ten follow-up samples did not detect cobalt-60.

At present, 52 samples of harbor sediment are taken at PSNS each quarter. Sampling locations are shown on Figure 6-1. Sample locations are selected based on berthing locations of nuclear-powered ships and at points upstream and downstream of berths where tidal ebb and flood currents could deposit suspended radioactivity.

A modified 6 inch square Birge-Ekman dredge is used to obtain a sample of the top 1/2 to 1-inch of the bottom sediment. This was selected since surficial sediments are more mobile and more accessible to marine life.

Prior to 1978, sediment samples were collected in 1-quart cylindrical containers and analyzed using a Sodium Iodide scintillation detector in conjunction with a 100 channel "Gammascopie." In 1978, a 4096 channel analyzer and germanium high resolution spectroscopy system was put into service, and actual cobalt-60 activities have been measured since then, in addition to gross gamma. Collected sample material was placed in Marinelli type containers to provide more consistent counting geometry.

Sample analysis is conducted using a standardized analysis procedure which has been approved by the NNPP. All Program Fleet and shore-based activities conducting environmental monitoring utilize this method.

The shipyard has utilized crosschecks by independent laboratories to verify our sample analysis results. This program continues through the present, utilizing an independent Department of Energy (DOE) laboratory. In addition, beginning in 1981, a test sample having a known quantity of cobalt-60 radioactivity has been sent to the shipyard by the laboratory annually for analysis. Shipyards are not provided with quantitative data beforehand. Analysis results are forwarded to the DOE laboratory for comparison with the DOE laboratory counting results and the activity known during sample preparation. Shipyard results have been consistent with DOE laboratory results. Tables 6-2 and 6-3 provide side-by-side comparisons of shipyard data and DOE laboratory data for routine shipyard samples, and for the DOE laboratory test samples, respectively.

PUGET SOUND NAVAL SHIPYARD
BREMERTON, WASHINGTON

ENVIRONMENTAL MONITORING LOCATIONS

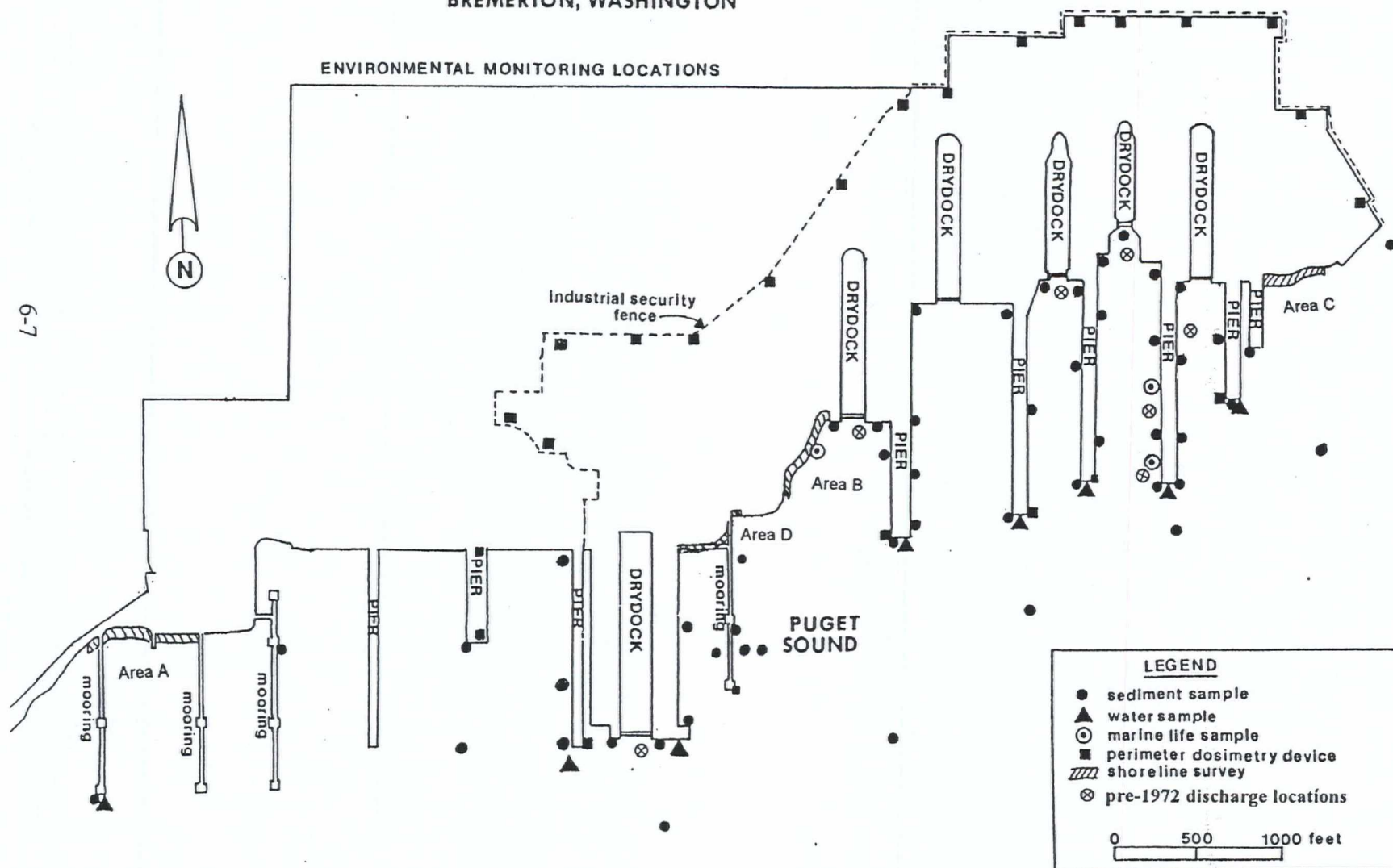


Figure 6-1
Environmental Monitoring Sample Locations

Table 6-2
Comparison of Shipyard and DOE Laboratory Data for Routine Sediment Samples (pCi/g)
(KAPL=Knolls Atomic Power Laboratory)

Gross Gamma (0.1 - 2.1 MeV)							
Year	No. of Samples	Average		Range			
		PSNS	KAPL	PSNS		KAPL	
				High	Low	High	Low
1993	21	0.71	0.749	1.16	0.385	1.13	0.480
1992	21	0.62	0.650	0.97	0.33	0.997	0.323
1991	21	0.68	0.704	1.00	0.45	1.06	0.462
1990	21	0.63	0.635	1.10	0.27	1.10	0.285
1989	21	0.69	0.665	1.01	0.48	1.11	0.482
1988	21	0.67	0.650	1.23	0.25	1.21	0.207
1987	22	0.77	0.722	1.46	0.45	1.05	0.271
1986	22	0.67	0.659	1.50	0.30	1.42	0.251
1985	21	0.88	0.865	1.79	0.21	1.86	0.122
1984	21	0.7	0.7	3.06	0.08	2.89	0.104
1983	22	0.6	0.5	1.43	0.09	1.13	0.096
1982	20	0.9	0.9	3.89	0.10	4.11	0.114
1981	20	0.8	0.8	2.32	0.17	2.51	0.114
1980	20	0.8	0.8	3.53	0.07	3.65	0.085
1979	16	1.1	1.0	4.66	0.13	4.52	0.189
1978	16	1.2	1.2	5.96	0.28	6.00	0.21

Cobalt-60 Energy Range (1.1 - 1.4 MeV)						
Year	Average		Range			
	PSNS	KAPL	PSNS		KAPL	
			High	Low	High	Low
1993	0.305	0.273	0.486	0.151	0.410	0.173
1992	0.27	0.269	0.46	0.12	0.439	0.119
1991	0.30	0.281	0.46	0.14	0.490	0.185
1990	0.27	0.266	0.49	0.10	0.473	0.110
1989	0.28	0.287	0.47	0.16	0.514	0.204
1988	0.27	0.263	0.43	0.08	0.413	0.089
1987	0.30	0.283	0.75	0.13	0.459	0.120
1986	0.25	0.284	0.46	0.07	0.502	0.119
1985	0.30	0.319	0.52	0.05	0.600	0.059
1984	0.3	0.3	0.73	<0.03	0.675	<0.039
1983	(a)	0.2	(a)	(a)	0.452	<0.037
1982	0.3	0.3	1.05	<0.04	1.23	<0.035
1981	0.3	0.3	0.61	<0.04	0.69	<0.035
1980	0.3	0.3	1.06	<0.04	1.08	0.085
1979	0.4	0.3	1.27	<0.04	1.23	0.036
1978	0.4	0.4	1.56	0.05	1.58	0.042

Note: (a) Analysis not performed.

Specific Cobalt-60 Photopeak						
Year	Average		Range			
	PSNS	KAPL	PSNS		KAPL	
			High	Low	High	Low
1993	0.069	0.037	0.120	0.019	0.050	0.026
1992	0.062	0.053	0.100	0.029	0.089	0.020
1991	0.064	0.062	0.110	0.028	0.095	0.039
1990	0.054	0.073	0.097	0.013	0.112	0.035
1989	0.07	0.051	0.12	0.03	0.079	0.016
1988	0.07	0.053	0.11	0.04	0.094	0.016
1987	0.06	0.056	0.12	0.03	0.090	0.030
1986	0.05	0.042	0.10	0.02	0.080	0.012
1985	0.07	0.057	0.11	0.04	0.091	0.027
1984	0.04	0.06	0.07	0.02	0.094	0.021
1983	0.05	0.06	0.08	0.02	0.095	0.022
1982	0.06	0.06	0.13	0.02	0.113	0.020
1981	0.06	0.06	0.12	0.02	0.087	0.035
1980	0.1	0.1	0.10	0.02	0.158	0.039
1979	0.1	0.1	0.16	0.02	0.147	0.020
1978	0.1	0.1	0.13	0.02	0.134	0.026

Note: The values for the Co-60 photopeak are the MDA. Actual samples were <MDA. This table presents data from one calendar quarter per year, when the KAPL comparisons were performed.

Table 6-3
Comparison of Shipyard and DOE Laboratory Data for Test Samples

Simulated Sediment (pCi/g)													
Year	Actual Conc. Co-60		Shipyard Measured Co-60		Actual Conc. Cs-137		Shipyard Measured Cs-137		Other Isotopes				
	Activity	+/-	Activity	+/-	Activity	+/-	Activity	+/-	Isotope	Activity	+/-	Activity	+/-
1993	2.00	0.06	1.80	0.29	2.00	0.08	1.80	0.28					
1992	1.05	0.03	1.00	0.20	1.15	0.05	1.00	0.21					
1991	1.10	0.03	1.00	0.21	1.10	0.05	1.10	0.20					
1990	1.12	0.03	1.00	0.21	1.06	0.04	1.10	0.20					
1989	1.09	0.03	1.16	0.23	1.36	0.05	1.28	0.22					
1988	1.05	0.03	0.99	0.22	1.11	0.05	1.02	0.19	Co-57	0.49	0.01	0.50	0.08
1987	0.90	0.03	0.85	0.19	0.85	0.03	0.78	0.19					
1986	1.14	0.03	1.13	0.21	0.87	0.03	0.82	0.15	Cr-51	9.38	0.24	8.72	0.67
1985	2.16	0.06	2.22	0.35	0.60	0.02	0.46	0.16	Co-57	0.47	0.01	0.50	0.07
1984	1.97	0.05	1.86	0.30	0.92	0.03	0.97	0.18	Co-57	0.59	0.02	0.61	0.11
1983	0.70	0.02	0.84	0.19	1.56	0.06	1.58	0.23	Cs-134	1.44	0.04	1.64	0.25
1982	1.28	0.03	1.21	0.29	0.80	0.03	0.84	0.19	Cr-51	3.46	0.09	4.12	2.29
1981	0.79	0.03	0.80	0.20	1.16	0.03	1.48	0.23	Mn-54	0.99	0.05	0.92	0.21
1980	1.05	0.26	0.90	0.22	1.10	0.21	1.16	0.22	Co-57	1.96	0.15	2.10	0.18

Simulated Air Patch (pCi)				
Year	Actual Activity Co-60		Shipyard Measured Co-60	
	Activity	+/-	Activity	+/-
1993	391	11	350	10
1992	191	6	160	43
1991	202	6	250	41
1990	199	5	190	36
1989	191	5	210	18
1988	218	5.7	201	6.5
1987	145	4	141	5
1986	168	4	159	28
1985	259	7	274	7
1984	288	8	289	8
1983	210	5	212	5
1982	142	4	139	5
1981	261	7	277	7
1980	184	5	223	7

Note: Error term (+/-) is given as 2 sigma counting error

In 1974, 1979, and 1983, the shipyard issued "Assessments of Environmental Radioactivity and Population Exposure Resulting from Operations Associated with Naval Nuclear Propulsion Plant Work at Puget Sound Naval Shipyard Bremerton Washington," References 16, 17, and 18. All of these assessments concluded that the shipyard has kept exposure to the general public and effluent to unrestricted areas as low as reasonably achievable and not distinguishable from natural background. Reference 18 used methods based on the requirements of Reference 19; these methods are used by the commercial nuclear industry in performing population dose estimate calculations for light water reactors.

During 1974 and 1987 the U. S. Environmental Protection Agency (EPA) conducted independent assessments of radioactivity in the environs of the shipyard. Measurements included radioactivity in harbor water, harbor bottom sediment and core samples, marine life, and ambient radiation levels. Radioactivity measurements and assessments of the results are reported in References 20 and 21. EPA results are consistent with shipyard environmental monitoring program results.

The 1974 Environmental Protection Agency survey concluded:

"The results of this study indicate the procedures utilized by the Navy to control the release of radioactive material into the Bremerton Harbor from PSNS are apparently effective.

"Levels measured are close to the detection limit for the most sensitive analytical equipment. This indicates that nuclear operations at the Puget Sound Naval Shipyard are not contributing a significant radiation exposure to the public.

"External exposure measurements in public areas indicate no exposure above natural background resulting from PSNS operations.

"The continuation of the current practices regarding waste discharge and the Navy monitoring program should assure continued absence of significant public exposure for routine nuclear ship operations."

The 1987 Environmental Protection Agency survey concluded:

"A trace amount of Co-60 (0.04 ± 0.01 pCi/g) was detected in one sediment sample at PSNS. All other radioactivity detected in the eighty sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons tests and the Cherbobyl reactor accident in 1986.

"Results of core sampling did not indicate any previous deposit of Co-60 in the sediment.

"Water samples contained no detectable levels of radioactivity other than those occurring naturally.

"External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels.

"Based on these surveys, current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in significant population exposure or contamination of the environment."

The State of Washington Department of Health has occasionally collected sediment and marine life samples from the shipyard environs or nearby locations. The State has also measured ambient radiation levels near the shipyard with thermoluminescent dosimeters. Results of this program have been included in the State's annual environmental monitoring reports and are consistent with the results of the shipyard's environmental monitoring program.

The data collected by the shipyard, the Environmental Protection Agency, and the State of Washington over the period 1963 through 1993 clearly support the conclusion that the levels of cobalt-60 detected in harbor sediment: a) contribute a negligible increase to background radioactivity levels; and b) pose no hazard to the public, either directly or via the food chain, and pose no hazard to the ecological systems of the region.

More recently, the Comprehensive Long-Term Environmental Action Navy (CLEAN) Program conducted harbor surface sediment and core sampling for hazardous substances both near shipyard piers and away from the shipyard. In May 1994, the shipyard collected samples in the same locations as the CLEAN Program samples for verification of radionuclide results. Since the CLEAN Program sediment samples were not all analyzed for radioactivity, the shipyard did not complete quantitative radioanalysis of corresponding samples. However, no cobalt-60 was detected in any shipyard sediment samples.

6.1.2 Harbor Water Monitoring

Beginning with the baseline data obtained in 1963 and continuing through the present, samples of water from the harbor have been collected and analyzed. Weekly samples were taken from 1963 through 1965. Quarterly samples have been taken since 1966. Current sampling locations are shown on Figure 6-1.

Sample locations are selected based on areas where radioactive liquids could have been discharged and at upstream and downstream locations.

From 1963 through 1965, 100 ml portions of harbor water samples were evaporated and counted for gross beta activity. Between 1966 and 1972, two-liter samples were evaporated to 400 ml and gamma counted with a 3" x 3" sodium iodide scintillation detector. A 100-channel analyzer was used to measure gross gamma activity in terms of cobalt-60 equivalent, and cobalt-60 energy range activity. Between 1973 and 1977, six-liter samples were counted in shipyard-made Marinelli containers with a 3" x 3" sodium iodide scintillation detector and a multichannel analyzer. Since 1978, a 4096-channel multichannel analyzer and germanium high resolution spectroscopy system has been used to count 500 ml samples, and actual cobalt-60 activity is determined. Like sediment samples, a Marinelli container is used for water sample analysis.

Since 1978, the counting procedure for water samples has been the same as for sediment samples. The quality control sample sent annually by the DOE laboratory serves to verify both sediment and water sample analysis results.

Water samples were taken by the U. S. Environmental Protection Agency (EPA) in 1974 and 1987. References 20 and 21 report that no cobalt-60 was detected in any water sample taken during these surveys. No cobalt-60 has been detected in any water sample taken by the shipyard since the inception of the monitoring program in 1963. A review of both shipyard gamma counting results and the series of environmental monitoring reports published annually by the Naval Nuclear Propulsion Program reveals that no cobalt-60 has ever been detected in harbor water samples. Quarterly data for each year is reported annually by the shipyard. The water sample data is not tabulated in this report since it reflects 30 years of less than minimum detectable activity values. Minimum detectable activities (MDAs) for harbor water cobalt-60 have ranged from 1.2×10^{-8} to 1.2×10^{-7} $\mu\text{Ci/ml}$ over the past 30 years.

The conclusions reached by the Navy in its annual reports are confirmed by References 20 and 21. The Reference 21 conclusion is quoted in Section 6.1.1.

6.1.3 Marine Life Sampling

As a part of the 1974 environmental assessment, Reference 16, marine life samples were collected and analyzed to determine if they may be concentrating the very low levels of radioactivity in the harbor environment. During June 1972, twenty-four marine life samples were collected from pilings and bulkheads in areas where wave and tidal action may have transported radioactivity. In July 1974 additional samples were collected from the harbor bottom in the vicinity of the point where processed water was discharged prior to mid-1972. The samples were analyzed for gross gamma radioactivity and radionuclide content with a gamma scintillation spectrometer. The following species of marine life were collected and analyzed:

Scientific Name	Common Name
Marine Plant: <i>Ulva linza</i> Linneaus	Green String Lettuce
Mollusk: <i>Protothaca staminea</i> <i>Venerupis staminea</i> <i>Callithaca tenerrima</i> <i>Mytilus edulis</i> <i>Saxidomus</i>	Littleneck Clam Thin-Shell Littleneck Edible Mussel Butter Clam
Crustacean: <i>Cancer productus</i>	Red Rock Crab

No cobalt-60 was detected in any sample.

Beginning in 1977, Program activities conducting environmental monitoring were required to obtain marine life samples during July of each year. Samples include available species of marine plants, mollusks, and crustaceans from sample locations shown in Figure 6-1. Analysis data of marine life samples taken since 1978 are shown in Table 6-4 (the species of mollusk collected varies from year to year).

Table 6-4
Marine Life Monitoring Results
Puget Sound Naval Shipyard

Year	Sample Type	Average Gross Gamma pCi/g	Average Cobalt-60 Energy Range Gamma pCi/g	Maximum Specific Cobalt-60 (a) pCi/g
1993	Crustacean	0.09	0.06	<0.05
	Mollusk	0.08	0.06	<0.03
	Marine Plant	0.19	0.14	<0.06
1992	Crustacean	0.12	0.12	<0.06
	Mollusk	0.14	0.08	<0.04
	Marine Plant	0.37	0.32	<0.08
1991	Crustacean	0.15	0.10	<0.06
	Mollusk	0.12	0.06	<0.09
	Marine Plant	0.15	0.12	<0.10
1990	Crustacean	0.11	0.12	<0.06
	Mollusk	0.05	0.06	<0.08
	Marine Plant	0.17	0.20	<0.09
1989	Crustacean	0.07	0.10	<0.09
	Mollusk	0.11	0.07	<0.06
	Marine Plant	0.22	0.22	<0.08
1988	Crustacean	0.08	0.07	<0.06
	Mollusk	0.11	0.08	<0.06
	Marine Plant	0.15	0.10	<0.09
1987	Crustacean	0.09	0.06	<0.04
	Mollusk	0.09	0.11	<0.06
	Marine Plant	0.12	0.14	<0.01
1986	Crustacean	0.14	0.11	<0.05
	Mollusk	0.10	0.17	<0.06
	Marine Plant	0.54	0.49	<0.07
1985	Crustacean	0.18	0.13	<0.06
	Mollusk	0.09	<0.06	<0.05
	Marine Plant	0.24	0.26	<0.07
1984	Crustacean	0.15	0.10	<0.07
	Mollusk	0.11	0.10	<0.07
	Marine Plant	0.19	0.16	<0.03
1983	Crustacean	0.15	0.15	<0.05
	Mollusk	<0.05	0.06	<0.05
	Marine Plant	0.21	0.21	<0.05
1982	Crustacean	0.08	0.07	<0.05
	Mollusk	0.08	0.10	<0.03
	Marine Plant	0.19	0.29	<0.03
1981	Crustacean	0.15	0.13	<0.09
	Mollusk	0.13	0.13	<0.03
	Marine Plant	0.33	0.23	<0.09
1980	Crustacean	<0.05	<0.05	<0.04
	Mollusk	0.13	0.11	<0.04
	Marine Plant	0.11	0.19	<0.04
1979	Crustacean	0.14	0.07	<0.04
	Mollusk	0.12	0.08	<0.07
	Marine Plant	0.21	0.21	<0.07
1978	Crustacean	0.10	0.10	<0.05
	Mollusk	0.06	0.10	<0.05
	Marine Plant	0.20	0.23	<0.12

Notes: (a) Samples analyzed with a high resolution germanium detector and 4096-channel analyzer.
All results were less than the MDA values shown.

Marine life samples were taken by the U. S. Environmental Protection Agency (EPA) in 1974 and 1987. Radioactivity measurements and assessment of the results are reported in References 20 and 21. No cobalt-60 was detected in any marine life sample taken during these surveys.

On the basis of the data shown in Table 6-4 and the findings of the EPA surveys reported in References 20 and 21, there has been no accumulation of cobalt-60 in marine organisms as a result of operation of nuclear-powered ships or work on those ships by PSNS.

6.1.4 Core Sampling

Core samples were taken as part of the environmental assessment done by the shipyard in 1974, Reference 16, and by the Environmental Protection Agency during 1974, Reference 20, and 1987, Reference 21. In 1977, NNPP regulations were revised to include core samples where sediment exceeded 3 pCi/g. As shown in Table 6-1, no sediment has exceeded this value; thus, no core sampling has been required to be done by PSNS since 1977. However core sampling was performed during two special environmental surveys by the shipyard in 1977 and 1979.

Core samples were taken to determine whether radioactivity may have accumulated below the top layer of sediment, which is sampled on a routine basis. Two 2-inch diameter by 12-inch deep core samples were collected at the locations designated in Table 6-5. Each sample was divided into segments, placed in a standard sediment sample container and analyzed for gross gamma radioactivity within the energy range of 0.1 to 2.1 MeV and within the energy range of cobalt-60 activity (1.1 to 1.4 MeV), using a gamma scintillation spectrometer.

Table 6-5
Radioactivity Analysis of Harbor Sediment Core Samples, July 1974

Sample Location	Depth inches	Wet Weight grams	Gross Gamma (0.1-2.1 MeV) pCi/g	Cobalt-60 Energy Range (1.1-1.4 MeV) pCi/g
Under Pier 6 (a)	0 - 1½ (c)	102	0.7	<0.4
	1½ - 3½	156	0.8	<0.2
	3½ - 5½	168	1.0	<0.2
	5½ - 7½	158	0.6	<0.2
	7½ - 9½	155	0.7	<0.2
	9½ - 11	211	1.1	0.3
South of Drydock #6 (b)	0 - 2½ (c)	325	0.8	0.2
	2½ - 4½	223	1.1	0.2
	4½ - 6½	236	0.9	0.2
	6½ - 12½	670	0.6	0.1

- Notes: (a) Previous liquid waste discharge point. Near the south end of Pier 6.
(b) Location selected because routine sediment samples in this area had consistently high gross gamma readings. High readings were later determined to be due to naturally occurring radium-226 and daughters.
(c) Top section of core included liquid.

No cobalt-60 was detected in either sample. The radioactivity detected in the cobalt-60 energy range was determined (by gamma spectrum analysis) to be due to naturally occurring radionuclides such as radium-226 and its daughters and potassium-40.

In January 1977 the shipyard took one core sample as part of a special environmental survey. The sample was taken east of Pier 3, about 300 feet from the south end of the pier. The sample was 14 inches long and two inches in diameter. It was divided into two inch segments for analysis. No radionuclides associated with the Naval Nuclear Propulsion Program were identified in any segment. Only natural radioactivity was identified.

Table 6-5 (con't)
Radioactivity Analysis of Harbor Sediment Core Sample, January 1977

Segment inches	Wet Weight grams	Gross Gamma (0.1-2.1 MeV) pCi/g	Cobalt-60 Energy Range (1.1-1.4 MeV) pCi/g
0 - 2	127	1.4	<0.3
2 - 4	144	1.9	<0.4
4 - 6	180	1.4	<0.3
6 - 8	154	1.3	<0.4
8 - 10	135	1.1	<0.4
10 - 12	150	0.9	<0.4
12 - 14	142	1.1	<0.4

Two core samples were collected by the shipyard in April 1979 as part of another special environmental survey. Both samples were collected south of the Drydock 6 caisson near the drydock's drain system outlet. Both were two inches in diameter. One was eight inches long and the other was ten inches. The samples were divided into two inch segments. To provide better analysis sensitivity the two inch segments from both samples were combined. No cobalt-60 or other radionuclides associated with the Naval Nuclear Propulsion Program were identified in any segment. Naturally occurring uranium and thorium daughters were identified in both samples. The levels found are consistent with routine sediment samples from this location and are at the high end of the range of gross gamma results from sediment samples reported in Table 6-1.

Table 6-5 (con't)
Radioactivity Analysis of Harbor Sediment Core Sample, April 1979

Segment inches	Weight grams	Gross Gamma 0.1 - 2.1 MeV pCi/g	Cobalt-60 Energy Range 1.1 - 1.4 MeV pCi/g	Specific Cobalt-60 1.32 - 1.34 MeV pCi/g
0 - 2	438	4.92	1.57	<0.19
2 - 4	476	4.04	1.19	<0.24
4 - 6	480	3.90	1.17	<0.20
6 - 8	478	4.24	1.29	<0.15
8 - 10	286	3.08	1.12	<0.19

The Environmental Protection Agency collected core samples at eight locations during October 1974 (Reference 20): four near Pier 6, two near Drydock 1, one east of Pier 3, and one south of Drydock 6. Reference 20 concluded that "The predominant activity found was from naturally occurring and typical fallout radionuclides. Only two samples collected at the south end of Drydock 6 had detectable amounts of cobalt-60." (Maximum level reported by Reference 20 was 0.62 pCi/g.)

The Environmental Protection Agency also collected core samples at three locations during late July and early August 1987, at the south end of Pier 6, south of Pier 9, and between Mooring A and Drydock 5. Reference 21 concluded that "All radionuclides identified in the ... cores were attributed to naturally occurring radionuclides or fallout. The radionuclide content of the core samples showed no significant differences with depth or with dredge samples taken at the same sites."

6.2 Dredging Records

Dredging is periodically conducted at PSNS to maintain the prescribed depth in slips, at various berths, and at the entrances to drydocks. Except for the most recent dredging (1987 - 1989), official records of dredging are not available. Except for 1987 through 1989, Table 6-6 is based on internal shipyard records.

Table 6-6
Dredging Conducted at Puget Sound Naval Shipyard

Year	Dredging Location(s)	Special Sediment Samples (#, specific cobalt-60)	Volume (Cubic Yards)
1994	West of Pier D	before 8, <0.08 pCi/g after 8, <0.09 pCi/g	105,100
1993	None	None	0
1992	None	None	0
1991	None	None	0
1990	None	None	0
1989 (a)	West of Pier B and east of Pier 3.	None	70,200
1988 (a)	West of Pier B and east of Pier 3.	None	
1987 (a)	West of Pier B and east of Pier 3.	20, <0.09 pCi/g	
1986	None	None	0
1985	None	None	0
1984	None	None	0
1983	Both sides of Pier 4.	NA, <0.2 pCi/g	7,500
1982	None	None	0
1981	Between Piers 5 & 6 and Piers 6 & 7.	None	7,000
1980	Between Piers 5 & 6 and Piers 6 & 7.	15, <0.12 pCi/g	56,400
1979	East of Pier 3.	6, <0.4 pCi/g	22,000
1978	Between Piers 5 & 6.	1, <0.4 pCi/g	NA
1977	None	None	0
1976	None	None	0
1975	None	None	0
1974	NA	NA	NA
1973	None	None	0
1972	None	None	0
1971	None	None	0
1970	NA	NA	NA
1969	None	None	0

Notes: (a) Dredging occurred between January 1987 and September 1989. Unspecified upland disposal site. Reference 22.

(b) NA means information was not available.

The amount of naturally occurring radioactivity removed from the region in the thousands of cubic yards of spoil, primarily potassium-40 in organic detritus, would far exceed the total upper limit cobalt-60 radioactivity found in shipyard sediment even if all the sediment removed from the shipyard contained cobalt-60 at the limit of detectability for the samples taken. This is based on information from Reference 12 on sea sediment potassium-40 content (5.7-32 pCi/g) and a cobalt-60 detectability limit on the order of 0.1 pCi/g.

6.3 Perimeter Radiation Records

Beginning in 1966, beta-gamma film badges were posted outside of controlled radiation areas to ensure that unmonitored personnel within the shipyard and the general public were not exposed to radiation levels above natural background.

In March 1969, the regulations were revised to include a group of film badges close to or at the perimeter of the shipyard. This second group of film badges provided additional data that no member of the general public living or working outside the shipyard exceeded the radiation exposure they would receive due to natural background, even if they lived or worked immediately adjacent to the shipyard perimeter 24 hours per day.

During the last two quarters of 1973 and first two quarters of 1974, both film badges and thermoluminescent dosimeters (TLDs) were posted in the same locations. For the third quarter of 1974 and all subsequent years, TLDs only have been posted at the shipyard perimeter. Figure 6-1 shows the locations of currently posted TLDs. Reference 23 provides an extensive discussion of the TLD perimeter radiation monitoring program.

During 1974, as reported in Reference 23, a special survey of the entire shipyard perimeter was performed using a gamma scintillation portable survey instrument (PRM-5N/SPA-3). The instrument was calibrated for gamma energies of greater than 0.1 Mev. Measurements made along the land perimeter ranged from 1.8 thousand counts per minute (kcpm) to 6.5 kcpm with a mean value of 4.1 kcpm. As a comparison, a survey was also performed at a Naval installation which was physically similar to the shipyard, but which had never performed radioactive work; readings obtained during that survey ranged from 2.5 to 5.0 kcpm with a mean value of 3.7 kcpm. Harbor property line measurements range from 0.7 kcpm to 5.0 kcpm with a mean of 2.9 kcpm. Variances of this magnitude are typical for background radiation, as shown in the aerial survey in Section 6.7.

During the first quarter of 1975, a comparative study was performed utilizing a pressurized ion chamber (Reuter-Stokes, RSS-111) and TLDs. Reference 17 reports the results of this survey. As shown in the following table, the pressurized ion chamber (PIC), TLDs, and values reported by the State of Washington Department of Health for Bremerton, show excellent agreement. These values also agree with the values reported by the Aerial Measuring System survey as discussed in Section 6.7. Table 6-7 shows that the TLDs provide a conservative estimate of environmental radiation levels.

Table 6-7
Natural Environmental Radiation Levels
Bremerton, Washington

	Avg. Dose Rate (μ rem/hr)	Avg. Yearly Dose (mrem)
WASH. STATE	6.3	55.5
PSNS PIC	6.0	52.6
PSNS TLD	7.3	64.4

Beginning in 1978, clusters of five TLDs were posted at background locations, replacing the single TLD posted previously. Examples of background locations include: Naval Undersea Warfare Engineering Station (Keyport), Marine Corps Rifle Range (Camp Wesley Harris), and Naval Fuel Depot (Manchester). This method provided a better statistical basis for background determination and improved reliability. Additionally, a special cluster was posted over water at Manchester to permit comparisons to the lower natural radioactivity of water as opposed to paving, concrete, and masonry structures typical at the shipyard.

Results of perimeter radiation monitoring are reported quarterly to the Naval Nuclear Propulsion Program. Since 1967, over 3000 data points have been obtained. Table 6-8 lists annual summary results of the PSNS perimeter monitoring program since the third quarter of 1973, when the use of TLDs was initiated. The results of the monitoring verify that radiation exposure to the general public in occupied areas surrounding the shipyard is indistinguishable from natural background.

Table A-1 of Reference 24 lists the annual total body dose due to natural sources in the vicinity of PSNS as approximately 87 mrem (9.9μ R/hr): 46 mrem is due to terrestrial sources of natural radioactivity and 41 mrem is due to cosmic radiation. Reference 24 is cited extensively by the National Council on Radiation Protection and Measurements (NCRP) as a continuing source of data for natural background radiation exposure estimates. This referenced estimate for natural background radiation exposure rate in the vicinity of PSNS is consistent with data in Table 6-9, which is a tabulation of values reported in References 16, 18, and 21, and EG & G aerial monitoring data (Section 6.7), along with PSNS fourth quarter data for 1993. (The results of one of the initial quarters of monitoring using TLDs are reported in Table II of Reference 17. Similar data for 1982 is reported in Table I of Reference 18. Reference 21 reports the results of the Environmental Protection Agency survey.)

Table 6-8
Perimeter Radiation Monitoring
Puget Sound Naval Shipyard
1974-1993

Year	Quarter	Land/Shoreline Posting	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
			Background	Perimeter	Background	Perimeter
1993	4	Land	14.0-16.6	14.3-17.3	15.1	15.7
		Shoreline	13.2-17.4	12.9-14.7	15.2	13.6
	3	Land	14.2-17.0	13.9-17.3	15.4	15.4
		Shoreline	12.6-14.8	12.9-14.8	13.4	13.6
	2	Land	13.5-16.7	12.2-17.0	14.7	14.8
		Shoreline	13.1-14.5	12.1-16.8	13.6	13.6
	1	Land	12.9-16.2	13.3-24.3	14.4	15.4
		Shoreline	12.4-14.3	10.1-15.4	13.4	12.9
1992	4	Land	13.9-16.3	13.5-17.2	15.1	15.1
		Shoreline	13.0-14.5	12.0-14.6	13.9	13.3
	3	Land	14.0-16.6	13.2-17.2	15.2	15.4
		Shoreline	8.6-14.1	12.6-14.4	12.7	13.4
	2	Land	12.9-17.8	13.2-16.3	14.8	14.8
		Shoreline	14.3-16.5	11.0-14.1	15.2	13.0
	1	Land	13.8-16.3	13.8-17.3	15.1	15.3
		Shoreline	11.6-13.5	12.1-17.0	12.8	13.7
1991	4	Land	15.6-18.1	14.2-18.2	16.5	16.4
		Shoreline	11.7-14.5	13.4-16.5	13.3	14.3
	3	Land	14.6-17.4	13.2-18.1	15.9	16.3
		Shoreline	12.8-13.9	12.6-14.3	13.3	13.5
	2	Land	12.9-16.3	13.6-16.4	14.8	15.2
		Shoreline	11.6-12.8	11.5-13.2	12.1	12.4
	1	Land	15.0-16.0	14.1-18.2	15.9	16.1
		Shoreline	13.1-14.3	12.8-14.3	13.6	13.6
1990	4	Land	15.0-16.5	13.3-18.2	15.8	15.8
		Shoreline	12.4-13.7	11.7-14.6	13.0	13.4
	3	Land	14.5-16.4	14.5-16.2	15.4	15.4
		Shoreline	11.6-13.7	12.8-13.7	12.7	13.3
	2	Land	14.4-16.4	13.7-16.9	15.5	15.6
		Shoreline	11.8-14.2	13.1-15.8	13.0	14.2
	1	Land	12.9-16.0	14.6-17.4	15.1	15.9
		Shoreline	11.3-13.6	12.0-14.5	12.3	13.3
1989	4	Land	14.5-16.2	13.8-17.6	15.5	15.7
		Shoreline	12.3-12.9	12.1-15.4	12.6	13.5
	3	Land	14.2-16.8	13.6-16.8	15.5	15.3
		Shoreline	11.3-12.2	11.5-16.2	11.8	13.0
	2	Land	14.2-16.8	14.2-18.7	15.4	15.9
		Shoreline	11.4-12.8	11.8-13.8	11.9	13.0
	1	Land	14.1-15.9	13.4-16.6	15.0	15.2
		Shoreline	11.7-12.3	12.4-14.0	11.9	13.0

Table 6-8 (cont)
Perimeter Radiation Monitoring
Puget Sound Naval Shipyard
1974-1993

Year	Quarter	Land/Shoreline Posting	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
			Background	Perimeter	Background	Perimeter
1988	4	Land	13.7-15.6	13.7-17.6	14.6	15.0
		Shoreline	10.3-12.3	11.7-13.3	11.6	12.6
	3	Land	13.4-15.6	13.1-15.7	14.4	14.6
		Shoreline	10.8-11.4	10.8-12.7	11.0	11.8
	2	Land	13.1-17.9	15.8-19.8	16.2	17.6
		Shoreline	12.9-15.1	13.7-15.4	13.7	14.4
	1	Land	16.6-18.4	14.6-18.5	17.2	16.8
		Shoreline	14.0-15.9	12.5-14.2	14.6	13.5
1987	4	Land	16.1-17.8	16.5-18.8	17.2	17.6
		Shoreline	14.1-15.9	12.8-15.1	14.8	14.3
	3	Land	15.4-16.8	15.7-17.8	16.4	16.6
		Shoreline	12.6-13.2	12.4-14.1	13.0	13.2
	2	Land	15.6-17.2	16.0-18.6	16.5	17.3
		Shoreline	12.9-13.4	11.0-14.8	13.1	13.5
	1	Land	15.2-17.0	14.9-18.4	16.1	16.7
		Shoreline	12.3-12.9	12.9-15.4	12.7	13.9
1986	4	Land	16.2-18.2	16.5-18.9	17.1	17.6
		Shoreline	14.5-15.9	13.3-15.3	15.2	14.5
	3	Land	16.3-17.7	15.4-19.0	16.9	16.9
		Shoreline	14.1-14.7	13.0-15.7	14.3	14.3
	2	Land	15.9-17.6	15.3-19.2	16.8	17.1
		Shoreline	13.9-15.3	13.4-15.9	14.5	14.2
	1	Land	15.1-16.5	15.4-17.9	15.7	16.4
		Shoreline	13.7-14.7	12.6-14.3	13.9	13.3
1985	4	Land	16.1-17.3	16.0-18.7	16.7	17.3
		Shoreline	14.4-15.1	13.4-15.4	14.9	14.2
	3	Land	15.0-16.1	14.9-16.9	15.7	15.9
		Shoreline	12.6-13.3	12.5-14.4	13.0	13.5
	2	Land	15.8-17.3	15.5-18.2	16.6	16.5
		Shoreline	14.2-15.1	13.1-15.8	14.5	14.2
	1	Land	16.2-17.5	16.6-19.0	16.9	17.6
		Shoreline	14.4-15.5	13.6-15.4	14.7	14.6
1984	4	Land	16.1-18.4	16.4-19.5	17.1	17.6
		Shoreline	15.0-15.3	12.9-16.4	15.2	14.5
	3	Land	16.2-17.7	15.6-18.6	17.0	17.0
		Shoreline	13.7-14.3	12.5-14.9	14.0	13.8
	2	Land	15.8-17.4	16.1-19.0	16.6	17.0
		Shoreline	14.1-14.7	13.2-16.0	14.3	14.2
	1	Land	14.8-17.0	14.8-17.8	15.5	16.2
		Shoreline	13.0-14.3	12.3-14.2	13.7	13.3

Table 6-8 (con't)
Perimeter Radiation Monitoring
Puget Sound Naval Shipyard
1974-1993

Year	Quarter	Land/Shoreline Posting	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
			Background	Perimeter	Background	Perimeter
1983	4	Land	15.3-17.1	14.6-18.0	16.2	16.6
		Shoreline	13.7-14.4	12.6-14.6	13.9	13.6
	3	Land	15.1-17.0	14.3-17.9	16.2	16.1
		Shoreline	13.5-14.6	12.1-13.8	14.0	12.9
	2	Land	14.7-17.0	15.1-18.6	16.4	16.8
		Shoreline	13.9-14.7	12.2-13.7	14.3	13.4
	1	Land	15.3-17.5	15.0-18.2	16.3	16.8
		Shoreline	13.1-13.9	12.8-14.7	13.4	13.5
1982	4	Land	15.5-17.0	14.0-17.8	16.3	16.6
		Shoreline	12.7-13.9	13.3-15.0	13.4	14.0
	3	Land	16.0-17.5	14.8-17.6	16.7	16.4
		Shoreline	12.1-12.6	12.1-14.1	12.4	13.1
	2	Land	15.4-16.8	14.6-17.0	16.0	16.4
		Shoreline	12.3-12.7	12.5-14.6	12.5	13.4
	1	Land	15.6-17.4	14.8-18.6	16.4	16.7
		Shoreline	12.4-14.1	12.8-14.6	13.0	13.6
1981	4	Land	15.4-17.6	15.5-18.8	16.5	16.9
		Shoreline	12.4-14.1	11.8-15.2	13.0	13.7
	3	Land	15.8-17.6	14.9-17.6	16.7	16.6
		Shoreline	12.6-13.0	12.6-14.8	12.7	13.4
	2	Land	15.6-16.9	14.6-17.5	16.1	16.1
		Shoreline	12.4-12.7	12.3-13.5	12.6	12.9
	1	Land	15.7-17.6	15.4-17.9	16.7	16.8
		Shoreline	12.5-13.4	12.7-13.9	13.1	13.3
1980	4	Land	15.1-17.1	14.9-18.1	16.0	16.5
		Shoreline	12.0-12.6	13.0-13.4	12.3	13.2
	3	Land	14.9-17.4	14.3-17.9	16.2	16.5
		Shoreline	12.0-12.3	12.6-13.7	12.2	13.0
	2	Land	14.8-17.1	14.8-19.2	16.1	16.8
		Shoreline	11.9-12.7	12.9-13.6	12.3	13.2
	1	Land	15.3-16.6	14.3-18.0	15.9	16.1
		Shoreline	12.1-13.0	12.5-14.3	12.6	13.4
1979	4	Land	14.6-17.0	15.4-18.9	16.1	16.6
		Shoreline	12.1-13.0	12.6-14.6	12.6	13.4
	3	Land	15.0-17.5	14.9-17.5	16.3	16.3
		Shoreline	12.5-12.9	12.2-14.4	12.7	13.1
	2	Land	14.3-16.6	14.6-17.1	15.6	15.8
		Shoreline	11.2-12.7	12.1-13.9	12.1	12.9
	1	Land	15.0-17.1	14.9-17.8	16.0	16.2
		Shoreline	12.4-12.9	12.1-13.2	12.6	12.8

Table 6-8 (con't)
Perimeter Radiation Monitoring
Puget Sound Naval Shipyard
1974-1993

Year	Quarter	Land/Shoreline Posting	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
			Background	Perimeter	Background	Perimeter
1978	4	Land	15.2-17.6	14.9-17.7	16.2	16.3
		Shoreline	12.1-13.3	11.8-13.9	12.6	13.1
	3	Land	15.5-17.2	14.6-17.9	16.4	16.5
		Shoreline	12.4-13.2	12.1-14.7	12.7	13.1
	2	Land	15.7-17.0	14.8-18.5	16.4	16.4
		Shoreline	12.4-12.6	12.6-13.7	12.6	13.1
	1	Land	15.5-17.2	15.3-18.4	16.4	16.6
		Shoreline	12.5-12.9	12.9-14.2	12.7	13.6
1977	4	Land	15.1-16.7	14.8-17.2	15.7	15.8
		Shoreline	12.0-12.6	12.6-14.1	12.3	13.3
	3	Land	15.3-17.6	14.9-18.0	16.6	16.4
		Shoreline	11.9-12.8	13.1-14.4	12.5	13.4
	2	Land	14.6-16.6	13.5-18.3	15.6	15.6
		Shoreline	12.1-12.2	11.8-13.0	12.2	12.4
	1	Land	14.6-16.2	14.1-17.6	15.4	15.8
		Shoreline	12.0-12.5	11.9-13.1	12.2	12.4
1976	4	Land	15.5-17.1	13.5-17.6	16.1	16.4
		Shoreline	12.1-12.4	11.8-12.8	12.3	12.3
	3	Land	15.2-16.8	14.4-17.9	16.2	16.3
		Shoreline	12.2-12.5	12.3-14.1	12.4	13.2
	2	Land	15.0-16.5	14.2-17.3	15.8	15.9
		Shoreline	11.8-12.9	11.8-13.5	12.4	12.8
	1	Land	14.9-16.7	14.1-17.0	15.8	15.9
		Shoreline	11.8-12.7	12.6-13.4	12.3	13.0
1975	4	Land	15.1-16.6	13.9-17.1	15.8	15.6
		Shoreline	11.9-12.2	12.1-13.6	12.1	12.9
	3	Land	15.4-17.1	14.7-17.5	16.2	16.2
		Shoreline	12.1-12.9	12.4-13.9	12.5	13.2
	2	Land	15.4-16.7	15.1-18.4	16.2	16.7
		Shoreline	12.3-12.9	12.6-14.4	12.5	13.5
	1	Land	15.3-16.6	14.0-17.0	15.8	16.0
		Shoreline	12.0-13.9	12.0-13.5	12.7	13.1
1974	4	Land	15.1-17.3	13.9-16.9	15.9	15.8
		Shoreline	11.8-12.3	11.2-13.5	12.1	12.7
	3	Land	15.3-16.9	15.1-17.3	16.2	16.3
		Shoreline	11.5-13.1	12.3-13.6	12.0	13.0
	2	Land	14.1-15.2	14.1-17.7	14.7	15.4
		Shoreline	14.1-15.2	12.2-12.6	14.7	12.5
	1	Land	13.7-16.9	14.0-18.9	15.3	15.3
		Shoreline	13.7-16.9	11.5-12.9	15.3	12.2

Table 6-9
Perimeter Radiation Monitoring Comparison
Puget Sound Naval Shipyard

Year	Survey	Ref.	Exposure Rate Range μR/hr	Average Perimeter Exposure Rate μR/hr
1993 4th Quarter	PSNS Quarterly Monitoring Data	N/A		
	Background Land		6.4 - 7.6	6.9
	Shoreline		6.0 - 7.9	6.9
	Perimeter Land		6.5 - 7.9	7.2
	Shoreline		5.9 - 6.7	6.2
1987	US EPA Radiological Survey	18	3.4 - 4.5	4.0
1983	PSNS Assess. of Environmental Radioactivity	13		
	Background Land		NA	7.4
	Shoreline		NA	7.4
	Perimeter Land		NA	7.5
	Shoreline		NA	6.0
1974	EG & G Aerial Radiological Survey	NA	3.5 - 8.0	NA
1974	PSNS Assess. of Environmental Radioactivity	14		
	Background Land		7.3 - 9.3	7.5
	Shoreline		7.3	7.3
	Perimeter Land		7.0 - 8.7	7.5
	Shoreline		6.0 - 6.5	6.2

Note: NA means either not applicable or information not available in the reference.

EPA concluded in Reference 20 that "External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels." This conclusion is consistent with the Navy findings reported annually for the past 25 years in Reference 15 and successive reports through Reference 9.

6.4 Shoreline Monitoring Records

Puget Sound Naval Shipyard has conducted gamma radiation surveys of selected shore areas uncovered at low tide since 1966. The purpose of this monitoring is to determine if any radioactivity has washed ashore. These surveys are conducted during the second and fourth quarters of the year. Areas are selected based on the likelihood of suspended radioactivity being deposited by tidal currents upstream and downstream of nuclear ship berthing areas. Two or more background readings are taken at least thirty feet from the high water line at each survey location.

Table 6-10 summarizes the results of these surveys taken since 1966. From 1966 through 1971, these surveys were obtained using a non-military portable gamma scintillation survey meter. A 1" x 1" detector was used from 1966 through 1968. A 1" x 2" detector was used from 1969 through 1971. Beginning in 1972 and continuing through the present, a PRM-5N/SPA-3 gamma scintillation survey meter with a 2" x 2" detector has been used. This instrument is calibrated to

permit distinguishing between natural and non-naturally occurring radioactivity; it is not calibrated for the direct conversion of count rate data to natural background radiation dose rates. Count rate data for the various instrument and probe combinations are not comparable.

Table 6-10
Shoreline Radiation Monitoring
Puget Sound Naval Shipyard
1972-1993

Year	Average Background Count Rate kcpm	Shoreline Count Rate Range kcpm
1993	3.4	1.6-9.5
1992	3.1	1.6-6.5
1991	3.5	1.4-7.1
1990	3.1	1.2-6.5
1989	2.9	1.2-6.0
1988	3.2	1.2-4.7
1987	3.5	1.8-5.9
1986	2.7	1.8-4.7
1985	2.7	1.8-4.7
1984	2.9	1.8-4.7
1983	2.7	1.8-7.1
1982	2.7	1.8-7.7
1981	2.4	1.8-7.7
1980	2.6	2.0-8.0
1979	2.9	1.8-7.8
1978	3.2	2.0-8.5
1977	3.0	2.0-7.5
1976	3.3	2.4-8.8
1975	2.9	1.8-7.5
1974	3.4	2.4-7.5
1973 (a)	3.7	1.9-9.0
1973 (a)	0.8	0.5-2.5
1972	0.8	0.6-1.8

Note:

(a) The calibration procedure for the instrument used to perform shoreline radiation monitoring was adjusted in 1973 to reflect an energy range of 0.1 MeV to about 8 MeV, vice 0.35 MeV to about 8 MeV. Thus, the higher shoreline survey results since mid-1973 include lower energy radiation from natural radioactivity.

Shoreline Radiation Monitoring
Puget Sound Naval Shipyard
1966-1971

Year	Average Background Count Rate cpm	Shoreline Count Rate Range cpm
1971	1,350	450-3,500
1970	1,300	750-3,500
1969	800	350-2,000
1968	200	100-700
1967	160	100-600
1966	175	100-600

As discussed in Section 3, the tidal currents in Sinclair Inlet are generally weak. Therefore, it is unlikely that suspended particulates would be transported more than a short distance away from the point of introduction. The selected shorelines for 1993 are shown on Figure 6-1 as "Area A," "Area B," "Area C," and "Area D." These areas are located within the shipyard and are thus readily accessible for monitoring by the shipyard. More detailed data for the four areas follows.

Table 6-11
Shoreline Radiation Monitoring
Puget Sound Naval Shipyard
Detailed Data 1989-1993

Year	Second Quarter Average, kcpm Second Quarter Range, kcpm					Fourth Quarter Average, kcpm Fourth Quarter Range, kcpm				
	Area A	Area B	Area C	Area D ^(b)	Bkgd	Area A	Area B	Area C	Area D ^(b)	Bkgd
1993	2.7 2.0 - 3.5	2.8 2.8 - 3.6	2.7 2.5 - 3.0	4.6 3.5 - 5.5	3.5 1.9 - 6.5	2.6 1.7 - 3.7	3.4 2.5 - 4.5	2.2 1.6 - 2.8	7.0 4.0 - 9.5	3.3 1.9 - 5.0
1992	2.8 1.6 - 5.3	3.0 2.5 - 3.5	2.4 1.8 - 3.0	4.0 2.9 - 5.5	2.8 1.9 - 5.0	2.6 1.8 - 3.5	3.3 2.1 - 4.5	2.1 1.5 - 2.6	5.1 3.8 - 6.5	3.4 2.0 - 5.0
1991	2.3 1.8 - 3.0	3.5 2.5 - 4.5	3.0 2.7 - 3.5	5.7 4.9 - 7.1	3.8 2.0 - 7.5	2.5 1.5 - 3.5	2.9 2.1 - 3.8	2.0 1.4 - 2.5	4.7 3.5 - 6.0	3.2 1.4 - 6.0
1990	3.3 1.5 - 6.5	2.7 2.5 - 3.0	3.0 2.6 - 3.5	4.4 3.0 - 5.6	3.2 2.0 - 5.0	1.9 1.5 - 2.5	2.7 2.0 - 3.5	2.1 1.2 - 2.8	4.0 3.0 - 5.5	3.0 2.0 - 6.5
1989	3.1 1.8 - 6.0	3.1 2.5 - 3.6	3.3 3.0 - 4.1	4.8 4.0 - 5.6	3.2 1.7 - 7.2	2.4 1.6 - 3.0	2.3 1.2 - 3.4	2.0 1.5 - 2.5	4.2 2.8 - 5.4	2.6 1.6 - 4.8

Notes: (a) Whenever area readings exceeded twice local background, they were followed up to determine the cause. In all cases, results were verified to be due only to naturally occurring radionuclides.
(b) Area D's historically elevated radiation readings are caused by naturally occurring radionuclides in concrete, slag, and sandblast grit.

The data of Table 6-10 shows that since 1967 there has been no measurable increase in radioactivity along monitored shorelines.

6.5 Storm Drain and Drydock Sampling Records

6.5.1 Storm Drain Sampling

In 1977, NNPP regulations were revised to include storm drain sampling in an annual sampling routine. These areas are likely to accumulate radioactivity in the event of an inadvertent radioactive discharge. Storm drains can also accumulate radioactivity from the run-off of precipitation, if inadvertent releases of radioactivity were not cleaned up properly or had occurred without proper reporting of the release. Samples are taken from storm drains near radioactive material storage areas and radioactive work areas. The results of the sampling are listed in Table 6-11. Sampling locations are shown on Figure 6-2.

6.5.2 Drydock Sampling

Drydocks routinely used by nuclear-powered ships are surveyed annually due to the potential to release radioactivity into the drainage and pumping systems. The results of drydock drain sampling are listed in Table 6-11. Sampling locations are shown on Figure 6-2.

Annual radiation surveys are also performed in drydocks when they are empty using a portable gamma survey instrument. The gamma radiation measurements are taken in a predetermined grid pattern covering the entire drydock floor. These surveys consistently find radiation levels indistinguishable from those in similar areas where no NNPP work has been performed.

The results show that NNPP activities have had no measurable effect on normal background radiation levels.

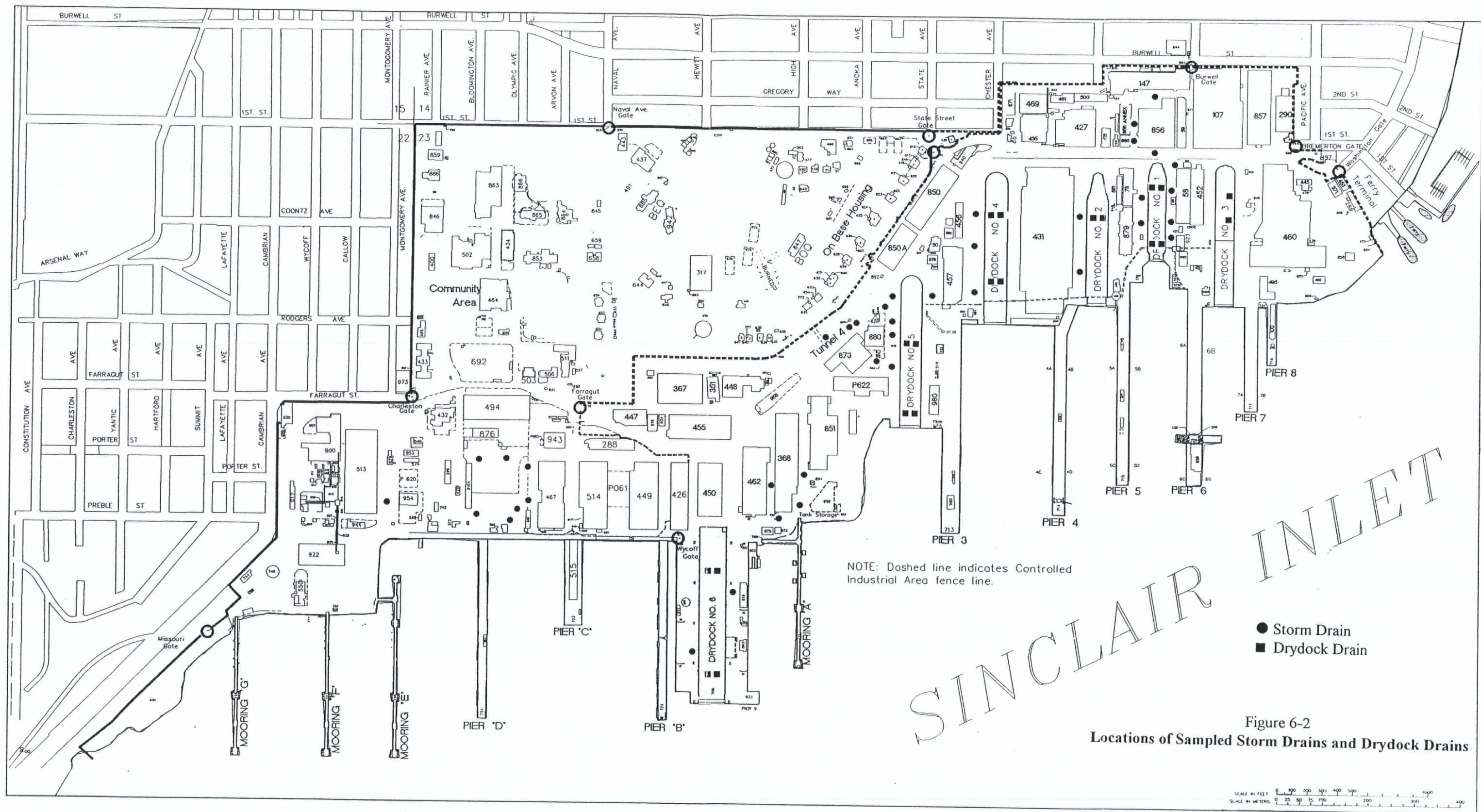


Table 6-12
Drain Sediment Samples
Puget Sound Naval Shipyard
1978-1993

Year	Number of samples		Range Gross Gamma 0.1 - 2.1 MeV pCi/g	Specific Cobalt-60 pCi/g	Samples with Cobalt-60 (a)
	Drydocks	Storm Drains			
1993	24	33	0.12 - 5.2	<0.014 - 0.80	0.80 pCi/g, Storm Drain west of Bldg. 368. (b) Three follow-up samples from adjacent drains and at outfall, no Co60 (<0.14 pCi/g).
1992	24	4	0.23 - 1.70	<0.015 - <0.13	
1991	24	6	0.24 - 2.30	<0.032 - <0.11	
1990	25	2	0.90 - 3.10	<0.039 - 1.60	1.6 pCi/g, Storm Drain west of Bldg. 368.
1989	22	4	0.82 - 2.70	<0.014 - <0.22	
1988	22	3	0.20 - 5.95	<0.05 - 0.89	0.89 pCi/g, Storm Drain west of Bldg. 368. 0.18 pCi/g, Drydock 2, NW center.
1987	22	4	<0.02 - 6.28	<0.04 - <0.30	0.15 pCi/g, Drydock 6, NE center.
1986	22	3	0.34 - 12.98	<0.02 - 0.41	0.41 pCi/g, Storm Drain south of Tunnel 4. (c) 0.16 pCi/g, Drydock 5 NE. 0.09 pCi/g, Drydock 4 SE. 0.14 pCi/g, Drydock 4 NE.
1985	22	4	0.29 - 3.57	<0.01 - 0.25	0.25 pCi/g, Storm Drain south of Tunnel 4. 0.08 pCi/g, Drydock 6. 0.05 pCi/g, Drydock 1.
1984	22	3	0.85 - 4.26	<0.03 - <0.11	
1983	18	3	0.50 - 3.88	<0.02 - 0.36	0.36 pCi/g, Storm Drain south of Tunnel 4. 0.15 pCi/g, Storm Drain east of Bldg. 513 near south end. (d)
1982	10	3	0.44 - 6.06	<0.02 - 0.35	0.35 pCi/g, Storm Drain south of Tunnel 4.
1981	18	2	2.06 - 5.41	<0.07 - 0.27	0.27 pCi/g, Storm Drain south of Tunnel 4. 0.27 pCi/g, Storm Drain east of Bldg. 513 near south end.
1980	18	2	0.9 - 5.2	<0.4 - <0.13	
1979	18	1	2.5 - 6.8	0.07 - <0.16	0.07 pCi/g, Storm Drain west of Bldg. 856. (e)
1978	17	4	1.1 - 8.5	<0.1 - <0.5	

Notes: (a) PSNS policy has been to resample adjacent to locations where cobalt-60 has been detected to determine if detectable radioactivity may be more widespread. For storm drains, the additional samples have been taken from adjacent upstream and downstream drains. These additional samples have never detected cobalt-60.

(b) Building 368 contains a radioactive material storage area.

(c) Tunnel 4 is a radioactive material storage area on Farragut Ave. across from Bldg. 873.

(d) Building 513 contained a radioactive material storage area until 1984.

(e) Building 856 contains a radioactive material storage area.

6.5.3 Conclusions

Only trace levels of cobalt-60 have been found in a few storm drain and drydock sump samples. This demonstrates that no significant amount of radioactivity associated with work on Naval nuclear propulsion plants has contaminated soil or ground coverings, as transportable via surface water run-off to the storm drain system or to the harbor via storm drain outfalls and/or drydock drains.

6.6 Routine Radiological Surveys

To ensure proper posting of radiation areas, gamma surveys are performed weekly in occupied radiological areas, including on piers and in drydocks alongside nuclear ships. Monthly surveys are performed on any potentially contaminated ducts, piping, or hoses in use. Surveys are performed quarterly in locked, unoccupied areas.

To verify no environmental release of contamination, surveys for loose surface contamination are conducted either each shift, daily, or weekly, depending on the work site and potential for release.

Searches are also conducted each month to identify any radioactive material (RAM) outside radiologically controlled areas. Searches using a beta-gamma frisker and a gamma scintillation type survey meter are performed in areas and buildings where no radioactive work is performed or radioactive material is stored. These searches are conducted on a revolving basis such that all parts of the Controlled Industrial Area are surveyed every three years. Search surveys are performed in outdoor areas, material travel routes, and inside buildings. These surveys frequently find radioluminescent dials from old watches and naturally occurring radioactivity in ceramic cups and ornamental planters. The surveys occasionally find uncontrolled NNPP radioactivity. The frequency of such findings averages about one or two per year. In most cases the items found meet the criteria for release from radiological controls, but are detectable by the search method. An example of how this can occur is a drawer full of small valves in a shop where each individual valve does not require control, but the combined low level radioactivity is detectable with the very sensitive instrument used for the search surveys. Of all the findings of the search surveys, only one involved release to the environment and listing on Table 5-4 (3/6/81 listing).

6.7 Aerial Radiological Survey

The Aerial Measuring Systems (AMS) program is managed by the Remote Sensing Laboratory in Las Vegas, Nevada, and operated for the Department of Energy by EG & G. Since 1958, hundreds of radiation surveys have been performed as part of the AMS program. EG & G aerial surveys of Department of Energy sites and radioactive waste disposal sites have demonstrated that the AMS can readily detect areas with surface contamination due to liquid or airborne releases and areas with buried radioactive waste.

In September 1974, an EG & G aerial monitoring survey was performed over the Bremerton, Washington, area. However, EG & G's report of the survey was not issued to the shipyard. The following is based on EG & G's original survey map and a summary of the standard EG & G aerial survey protocol as performed in 1981 over Norfolk Naval Shipyard.

A seven by eight mile survey area centered on Bremerton and encompassed most of Port Orchard and Gorst. The helicopter used for the survey flew at an altitude of 400 feet and all readings were extrapolated into data results at 1 meter above ground level. The results of the survey are shown in Figures 6-2 and 6-3, which were copied from the original survey map. Survey results are reported as radiation exposure rates in microrentgen per hour ($\mu\text{R/hr}$). The radiation exposure rates reported include terrestrial gamma radiation measured throughout the survey area and an estimated 3.5 $\mu\text{R/hr}$ cosmic ray exposure rate. The lowest readings (less than 3.5 $\mu\text{R/hr}$) were over water. Most of the higher terrestrial background levels (5.5 to 6.5 $\mu\text{R/hr}$) correspond to high concentrations of building or paving materials. The three "peak" shipyard areas are labeled C on the maps (6.5 to 8.0 $\mu\text{R/hr}$) and correspond (from west to east) to:

1. A fill area in the west end of the shipyard known to contain fire brick and sandblast grit (i.e., natural background radioactivity).
2. Building 513 radioactive material storage area (radioactive material has since been removed and the area released from radiological controls).
3. The Radiological Repair Facility, Building 839, on Pier 6. Concentric circles around Building 839 indicate highly localized sources located in the building.

Aerial monitoring survey results were slightly lower than the average 1974 land and harbor perimeter TLD results. The aerial survey places most of the shipyard's land perimeter in area B, 5.5 to 6.5 $\mu\text{R/hr}$. The average 1974 land perimeter TLD reading was 64.3 mrem/year or 7.4 $\mu\text{R/hr}$. The aerial survey places most of the shipyard's harbor perimeter TLD locations in area A, 3.5 to 5.5 $\mu\text{R/hr}$. The average 1974 harbor perimeter TLD reading was 52.1 mrem/year or 6.0 $\mu\text{R/hr}$.

With the exception of known radiological work and storage locations (active at the time of the survey) and the fill area in the west end of the shipyard, the radiation levels of the shipyard property as measured by the EG & G aerial monitoring survey are no different than those found in the survey areas remote from any shipyard activities. This survey is credible independent evidence that there are no locations within the shipyard, other than active facilities, where non-natural radioactivity is present.

Figure 6-3
EG & G Aerial Monitoring Survey

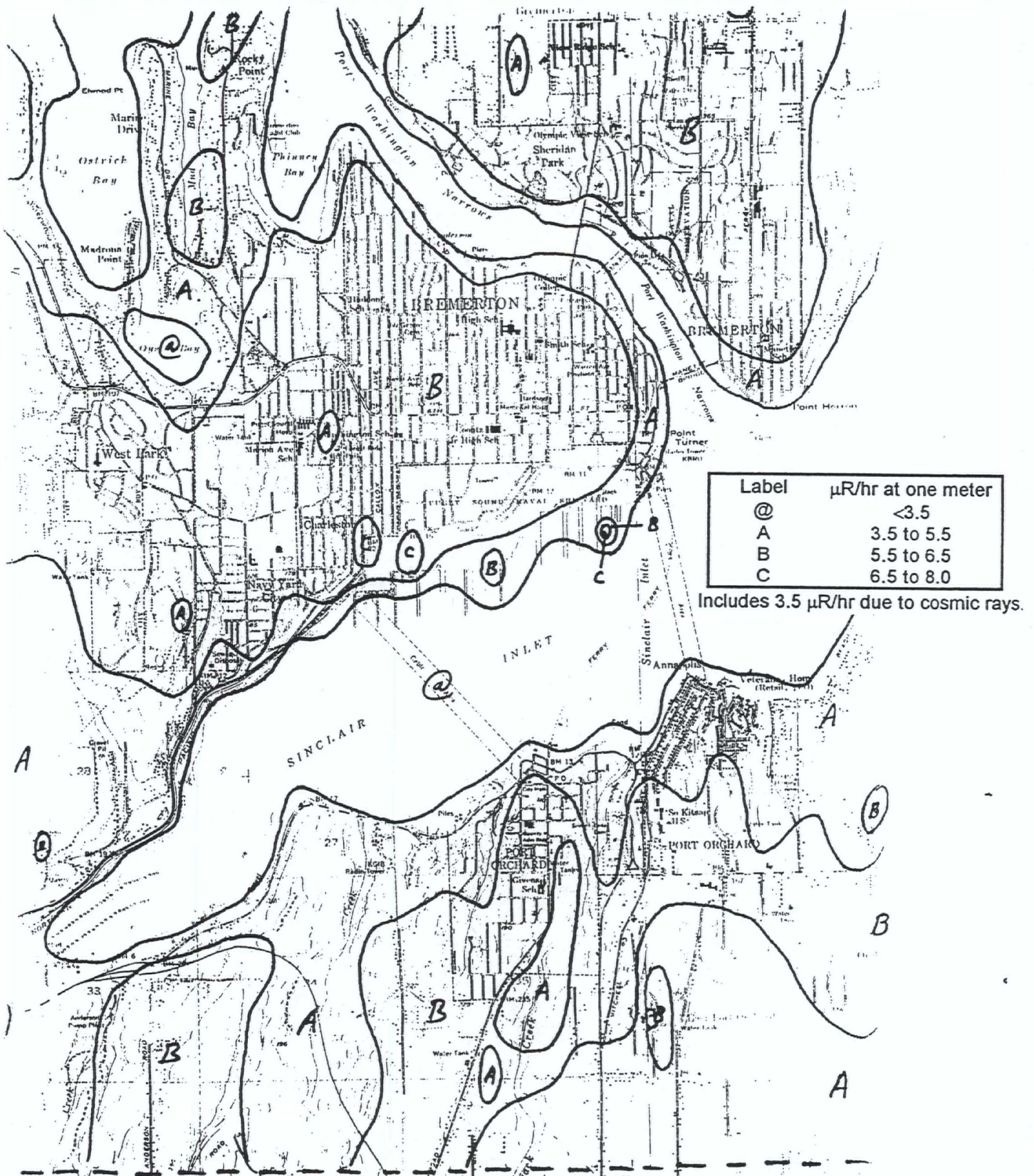
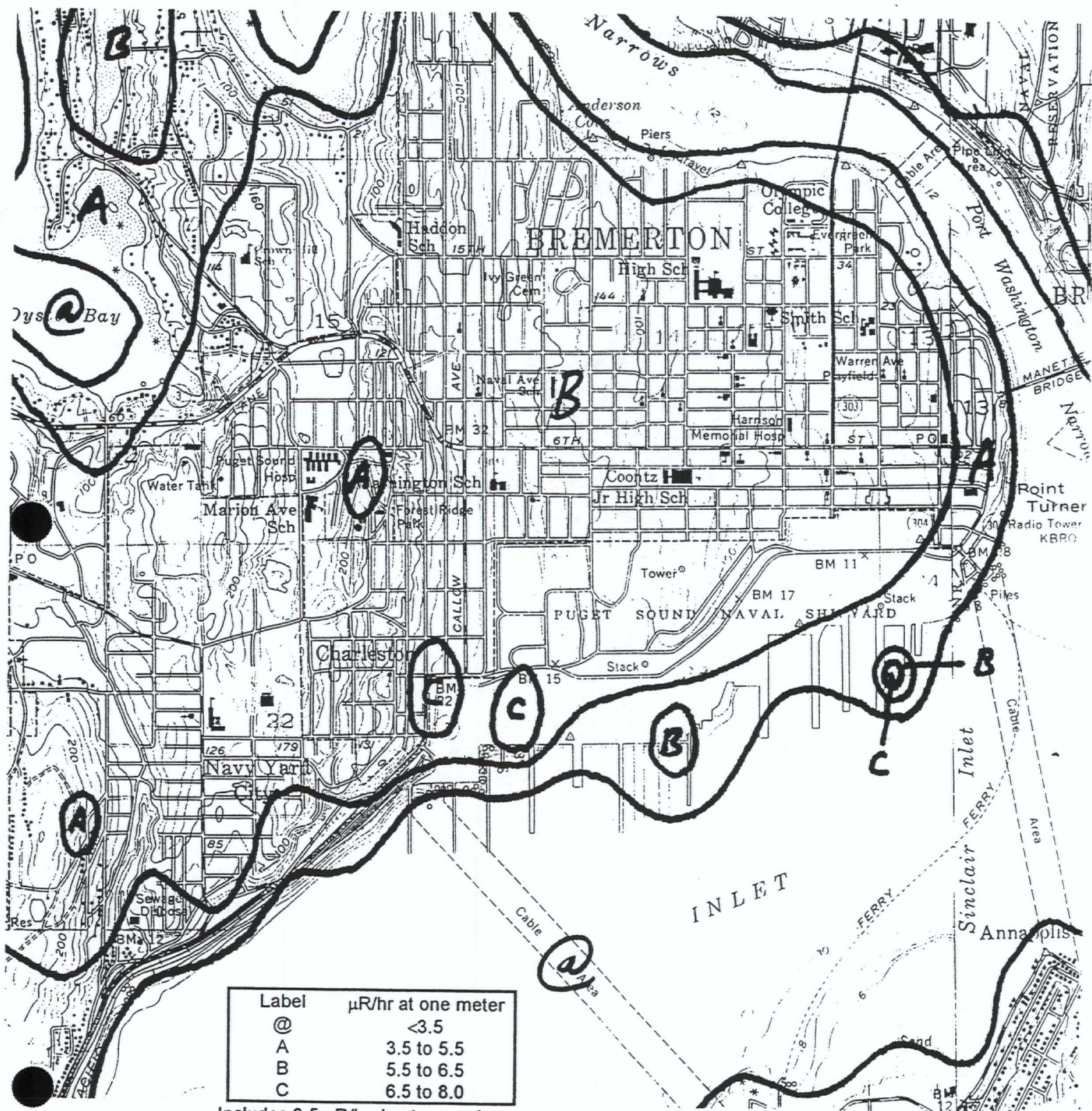


Figure 6-4
EG & G Aerial Monitoring Survey
Shipyard Detail



7.0 Residual Radioactivity

Of all the environmental radioactivity data collected, analyzed, and reported by the shipyard since 1963 and by the U.S. Environmental Protection Agency in 1977 and 1989, the only radioactivity remaining in the environment attributable to NNPP work at PSNS is trace amounts of cobalt-60 found in a few surface sediment samples and two core samples taken from the bottom sediment near piers.

The highest reported cobalt-60 activity was 0.62 pCi/g found in a sediment core sample about 5 centimeters beneath the bottom surface and reported in 1977 (October 1974 data) by the Environmental Protection Agency. This sample, if counted in 1994, would have decayed to 7 percent of its reported value or to 0.04 pCi/g.

Of particular significance, the radioactivity found in core samples is localized and occurs below the surface of the harbor floor. The sediments overlying the radioactivity identified in the core sample effectively isolate this activity from the harbor water, from harbor biota, and from harbor users.

The highest surface sediment sample with detectable cobalt-60 was 0.09 pCi/g, found by the EPA in 1974. This sample, if counted in 1994, would have decayed to 7 percent of its reported value or to 0.006 pCi/g, which would not be detectable.

The only detectable cobalt-60 found by the EPA in 1987 was a surface sediment sample with 0.04 pCi/g. This sample, if counted in 1994, would have decayed to 40 percent of its reported value or to 0.02 pCi/g.

By remaining in-situ, the process of radioactive decay will remove the radioactivity from the environment naturally and with far less impact on the ecosystems of the area than would be caused by artificial removal via extensive dredging.

8.0 Assessment of Environmental Impact

Reference 25, "Guidance for Performing Preliminary Assessments under CERCLA," lists four pathways of possible environmental transport, each evaluated by three elements. These pathways include ground water, surface water, soil exposure, and air. The elements are the likelihood of release (including the likelihood of a substance migrating through a specific pathway), the waste characteristics, and the targets.

The following sections evaluate the data and information presented in this report within the framework of Reference 25.

Reference 18 calculates the annual dose to individuals from pathways derived from the requirements of 10 CFR 50 (Reference 19). Elements of the 10 CFR 50 pathways are comparable to the air, soil exposure, and surface water pathways evaluated by the protocol of Reference 25. It is informative to compare the results of these assessments in order to quantify the potential exposures via the pathways considered in Reference 25.

8.1 Ground Water Pathway

The ground water pathway considers potential exposure threats to drinking water supplies via migration to and within aquifers. It may also impact surface water and areas where ground water discharges.

As discussed in Section 3, the shipyard's Controlled Industrial Area is mostly (about 95%) covered with paving or structures that isolate the soil zone from any potential release mechanisms discussed below. This condition has not changed significantly during the period being evaluated. Without access to the soil, percolation into the upper aquifer cannot occur. That no radioactivity to infiltrate the aquifer exists above background levels is established in evaluating the soil exposure pathway in Section 8.3.

As discussed in Section 3.3.3.3, there are two aquifers underlying the Kitsap Peninsula on which PSNS is located; however, there is no indication of aquifer interconnections. Flow in both aquifers underlying the shipyard is toward Sinclair Inlet. No drinking water is obtained from Sinclair Inlet. Public consumption and domestic wells are upgradient and thus isolated from the potential for contamination from the shipyard.

8.1.1 Release Mechanisms Affecting Ground Water

Radioactivity being released to ground water is the least likely mechanism. This could conceivably occur as a result of a release to the soil, atmosphere, or surface water. The radioactivity, which is primarily in an insoluble particulate form, would have to infiltrate through the soil to the ground water. As discussed above and in Section 3, no drinking water wells would be affected.

8.1.2 Ground Water Targets

Primary targets are defined as populations served by drinking water wells that are suspected to have been exposed to a hazardous substance. There has been no suspected NNPP radioactivity release from the site to ground water; thus, no primary targets are identified.

Secondary targets include populations served by all drinking water wells within four miles of the site that are not suspected to have been exposed to a hazardous substance. Table 3-3 lists public water supply sources within a 4-mile radius of the shipyard. In addition, Reference 3, Appendix H-3, Existing Well Data Pertinent to HRS Scoring, lists drinking water wells within four miles of the shipyard.

Figure 2-9 of Reference 3 incorrectly lists the Mullenix Maintenance Well as being in township 24N 1E 24C and therefore near the shipyard (about one quarter mile from the shipyard's northeast corner). Its correct location is 23N 1E 24C south of Port Orchard near Mullenix Road and Highway 16 (over six miles from the shipyard). The nearest drinking water well is in Port Orchard, 1.0 mile from the shipyard across Sinclair Inlet. Based on ground water flow, any potential contaminants that infiltrated into ground water at PSNS would be expected to discharge into Sinclair Inlet (the only surface water body receiving ground water from the shipyard); it is not credible that they might affect upstream wells, or wells across the Inlet.

There are no Wellhead Protection Areas within the region. Since ground water within the four mile zone has uses other than drinking water, it would be considered a resource.

8.1.3 Ground Water Pathway Assessment

There has been no identifiable release of radioactivity which could threaten the ground water in the vicinity of the shipyard and no mechanism by which a potential contaminant could be transported to ground water users. Since ground water flow is into the harbor, harbor monitoring would detect any accumulation of environmental radioactivity from the ground water pathway; such monitoring has found no evidence of environmental radioactivity release via ground water.

8.2 Surface Water Pathway

The surface water pathway considers potential exposure threats to drinking water supplies, to human food chain organisms, and to sensitive environments.

The only body of surface water associated with the shipyard is Sinclair Inlet, a salt water estuary. The Inlet is not a supply of drinking water.

Analytical data collected by the shipyard consisting of harbor water, biota, and sediment samples, along with data reported in 1974 and 1987 by the Environmental Protection Agency, have not

detected cobalt-60 in any water or marine biota since sampling was begun. Isolated and localized trace levels of cobalt-60 have been found in sediments but, as concluded by the EPA in references 20 and 21 (and quoted in Section 6.1.1), this radioactivity results in no significant population exposure or contamination of the environment.

Due to weak currents as discussed in Section 3.3.3.4, any contaminant introduced in the inlet near the shipyard will not be transported away from the point of entry but will remain in the area of introduction to be consolidated in bottom sediments.

There are no primary sensitive environments within the 15-mile tidal influence zones of concern. Secondary sensitive environments consist of wetlands along the shorelines. Wetlands frontage exceeds 20 miles.

8.2.1 Release Mechanisms Affecting Surface Waters

Air release mechanisms can disperse radioactivity to local surface waters, but the potential effect of low level discharges via the air pathway is very small. Of greater potential concern would be direct liquid and solid material discharges to surface water. Leaks or ruptures from tanks stored or being moved pierside could spill their contents into the harbor; the NNPP has a periodic maintenance program for radioactive liquid tanks which includes visual inspections inside the tanks and hydrostatic tests to help prevent potential leaks. Additionally, spillage of radioactive liquids to the shipyard storm drain system could ultimately reach the harbor. Leakage to ground water could also pass to surface water, should it ever occur.

Based on the rarity and trace level of detectable soil contamination in isolated samples from drydock and storm drains, and the immediate containment and recovery actions taken for spills, PSNS considers potential sources of radioactivity in surface water other than direct introduction to be insignificant.

8.2.2 Surface Water Targets

Surface water targets are subdivided into drinking water, human food chain, and environmental.

There are no intakes within the target distance limit as defined in Reference 25. As a drinking water supply, there is no resource within the target distance limit.

Sport and commercial fishing occur within the 15 mile target distance limit. As stated in Section 3.3.3.4, Sinclair Inlet has been closed to shellfish harvesting since 1982 because of bacterial contamination. The estimated production of 10,000 to 100,000 pounds per year for the shellfish fisheries was based on harvest/production values prior to this closure. Production of all species of salmon in the Kitsap basin ranged from 200,200 to 462,100 pounds per year for 1966 to 1971 (peak years). The smelt and herring harvests are estimated to be greater than 1,000 to 10,000 pounds per year. Reference 3 includes the above and additional information.

Table 8-1 lists all surface water bodies within the 15 mile tidal influence zone.

Table 8-1
Water Bodies Within the 15 Mile Tidal Influence Zone

Gorst Creek Anderson Creek	<u>Sinclair Inlet</u>	Ross Creek Blackjack Creek
	<u>Port Washington Narrows</u> Anderson Cove Phinney Bay	
Mud Bay Ostrich Bay Oyster Bay Chico Bay	<u>Dyes Inlet</u>	Chico Creek Mosher Creek Barker Creek Clear Creek
Fletcher Bay Burke Bay	<u>Port Orchard</u>	Crouch Creek Manzanita Bay
	<u>Liberty Bay</u>	
	<u>Agate Passage</u> (flows into Puget Sound)	
	<u>Rich Passage</u> (flows into Puget Sound) Clam Bay Beaver Creek	
	<u>Yukon Harbor</u> Curley Creek	

Wetlands within the 15-mile radius of PSNS are extensive. Along the Sinclair Inlet shoreline alone, the linear footage of wetlands exceeds 20 miles as measured on the 1990 Wetlands Inventory Map of Sinclair Inlet-Puget Sound as prepared by the Wetlands Section, Shorelands Program of the Washington Department of Ecology. However, the dynamics of transport of particulate cobalt-60, if any were present, and the Inlet's weak tidal currents, combine to make it unlikely for any radioactivity to reach even the closest wetland area.

Figure 2-10 of Reference 3 (Ecological Inventory, Puget Sound Naval Shipyard) illustrates the ecological inventory of terrestrial and aquatic environments surrounding PSNS within the 15-mile and 4-mile radii. Specific sensitive environments include: Sinclair Inlet as part of the National Estuary Program, Sinclair Inlet and streams as spawning areas for fish/shellfish, surrounding streams as migratory pathways for anadromous fish, migratory bird over-wintering habitat, and nesting areas for the bald eagle.

No national parks or monuments, national seashore recreational areas, national preserves, or federal wilderness areas have been identified within the tidal influence zone.

Illahee, Fort Ward, Manchester, and Blake Island State Parks all have tidelands within the 15 mile tidal influence zone. Recreational harvesting of shellfish occurs on these tidelands.

There are no listed or proposed endangered species which have been identified as having habitat on the shipyard. The only federal endangered species known to exist in Kitsap County are the bald eagle and the spotted owl; the nesting habitats of these species are found in the old growth forests of the Olympic National Forest. Blake Island is also a special habitat and nesting area for the bald eagle and is within a 15-mile radius of PSNS.

8.2.3 Surface Water Pathway Assessment

Previous sections of this report have established that no drinking water intakes from either surface or ground water are utilized or could be affected by any potential release via discharge, precipitation run-off, or percolation. Surface drainage (precipitation run-off and run-off of accidental discharges, if any) is always toward Sinclair Inlet. The nearest drinking water intake from surface waters is at Kitsap Lake, 3 miles from the shipyard. The potential for percolation is minimized because paving and structures isolate 95% of the soil zone from any release. If percolation did occur it would be to Sinclair Inlet.

Although there are extensive wetlands within the 15-mile tidal influence zone, the dynamics of transport of particulate cobalt-60, if any were present, are such that it is unlikely for any radioactivity to reach even the closest wetland area.

Table VI of Reference 18 lists estimated annual exposures to the maximally exposed individual from ingestion of aquatic organisms and from recreational use of Sinclair Inlet from cobalt-60 and tritium. Uniform distribution of radioactivity in water, sediment, and on the shoreline is also assumed. Table 8-2 is based on Reference 18.

Table 8-2
Estimated Annual Dose to an Individual from Maximum Annual Liquid Effluent Release

Pathway	Cobalt-60		Tritium	
	Critical Organ	Estimated Dose millirem	Critical Organ	Estimated Dose millirem
Ingestion of aquatic organisms	Lower large intestine	2.0×10^{-5}	Whole body	3.1×10^{-5}
Shoreline	Whole body	2.3×10^{-4}		
Swimming	Whole body	2.6×10^{-5}		
Boating	Whole body	1.5×10^{-5}		

These calculated values are based on the maximum assumed annual release of 0.001 curie for cobalt-60 and 0.100 curie for tritium. These values conservatively bound the levels of radioactivity in several thousand gallons of unprocessed reactor coolant; such a release has not occurred in over 20 years. Hence, these are very conservative estimates.

According to Table 9-7 of Reference 6, the annual dose to an individual due to radionuclides in the body (primarily potassium-40) is about 40 mrem. When this value is compared to the dose due to ingestion of seafood in Table 8-2, were the seafood contaminated with the maximum conceivable level of NNPP radioactivity, it is seen that radiation exposure due to the consumption of seafood is about 0.0001 percent of the dose due to natural radionuclides in the body. is about 0.0001 percent of the dose due to natural radionuclides in the body.

PSNS concludes that radioactivity in surface waters will not damage sensitive environments as described by Reference 25. As discussed above and in Section 6, no water or marine biota samples have shown levels of cobalt-60, nor have any shorelines within the littoral zone accumulated any radioactivity associated with the NNPP. This evidence supports the conclusion that there has been no environmentally detrimental release of radioactivity to surface waters surrounding the shipyard.

8.3 Soil Exposure Pathway

The soil exposure pathway considers potential exposure threats to people on or near the site who may come into contact with a hazardous substance via dermal exposure, soil ingestion, or plant uptake into the human food chain.

The shipyard is actively engaged in NNPP work. As such, there are radiological facilities containing radioactivity associated with this work. These facilities and the radiological controls applied to prevent contamination of workers and the environment are discussed in other sections of this report.

For areas and facilities other than those discussed above, this report concludes that there is no likelihood for exposure to humans or to the environment. This conclusion is based on the following:

- Perimeter radiation levels have consistently been comparable to background radiation levels as measured by the shipyard, Environmental Protection Agency, and EG & G.
- Shoreline surveys found no radionuclides along the shore attributable to Naval Nuclear Propulsion Program activities.
- Results of storm drain and drydock surveys and samples have not shown any significant amounts of cobalt-60 radioactivity.
- An aerial radiological survey conducted by EG & G identified controlled radiological work and storage areas, but did not find other areas within or adjacent to the shipyard with radiation levels higher than background.
- There has been no solid NNPP radioactive waste disposal on or near shipyard property, as documented by regulatory prohibition, review of historical disposal records, and review of measured radiation levels.

Since the above evidence would result in a "no likelihood of exposure" finding, the other elements of the soil exposure pathway do not need to be evaluated.

8.3.1 Release Mechanisms Affecting Soil

The release mechanisms discussed in the air pathway section could deposit radioactivity in the soil of affected areas. Radioactive liquid spills to the soil would be much more localized and concentrated than soil contamination resulting from low level airborne radioactivity releases. Liquid spills with the highest potential for reaching the soil are related to activities performed outside of radiological work areas. These activities include connections of tanks to ships, tank to tank transfers, movement of tanks within the shipyard, and the movement of smaller liquid containers such as plastic bottles. Spills of radioactive liquids inside work facilities would generally be contained within that facility, but could reach the soil through cracks in building materials or by leaching through porous building materials such as concrete. Also, in the event of a fire in a work facility, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the soil.

8.3.2 Soil Exposure Targets

PSNS is a military controlled access area and the public does not have immediate or easy access to any area, other than the Helicopter Pad Area in the extreme west end of the shipyard. All areas adjacent to NNPP work areas at PSNS are designated for industrial use.

There are no residences, schools, or daycare facilities within 200 feet of any potential source. For each Study Site, Reference 3 (Appendix H-1, Population Data Pertinent to HRS Scoring) lists the estimated target populations within 0 - ¼ mile, ¼ - ½ mile, ½ - 1 mile, 1 - 2 miles, 2 - 3 miles, and 3 - 4 miles. Population data for Study Site 8 is most representative of shipyard NNPP work areas. Table H-5 of Reference 3 is the basis of Table 8-3.

Table 8-3
Estimated Target Populations from Study Site 8

Radius	Nearby Individuals	Workers	HRS Total Population
0 - ¼ mile	0	>50 - 99	31 - 100
¼ - ½ mile	10 houses (60) barracks (800)	>500	1,001 - 3,000
½ - 1 mile	>1,500	>1,000	1,001 - 3,000
1 - 2 miles	38,000 - 50,000	0	30,001 - 100,000
2 - 3 miles	50,000 - 99,000	0	30,001 - 100,000
3 - 4 miles	50,000 - 99,000	0	30,001 - 100,000

No hospitals are within one mile of the shipyard. The following schools are within one mile of shipyard NNPP work areas: Naval Avenue, Star of the Sea Catholic, Marion Avenue, Bremerton High, Olympic College, Manette, and Navy Yard City.

There are no terrestrial sensitive environments that have been identified within a four-mile radius of the shipyard.

There is no land resource use for commercial agriculture, commercial silviculture, or commercial livestock production or grazing within a four-mile radius of the shipyard.

8.3.3 Soil Exposure Pathway Assessment

The ground deposition element in the airborne pathway of Reference 18 is directly related to the soil exposure pathway. For this calculation only cobalt-60 is considered since, of the radionuclides listed in Table V of Reference 18, it is the only particulate. Although most noble gases have particulate daughters, the transport of the gaseous parent disperses and dilutes the eventual dry deposition and rainout of particulate daughters to such an extent that their dose contribution is negligible.

Table A-1 of Reference 24 lists the annual total body dose due to natural sources in the vicinity of PSNS as approximately 87 mrem (9.9 $\mu\text{R/hr}$): 46 mrem (5.2 $\mu\text{R/hr}$) is due to terrestrial sources of natural radioactivity and 41 mrem (4.6 $\mu\text{R/hr}$) is due to cosmic radiation. Reference 24 is cited extensively in Reference 6 as a continuing source of data for natural background radiation exposure estimates. This value is consistent with data presented in Reference 18, with shipyard perimeter surveys, with surveys done by the EPA, and with the EG & G aerial survey.

The maximum individual annual total body dose due to soil exposure from 0.001 curie of cobalt-60 ground deposition would be about 0.08 mrem, as listed in Table V of Reference 18. Table 5-3 shows that the calculated maximum airborne release of NNPP radioactivity occurred in 1981 and totalled 4.4×10^{-5} curie. Presuming all this activity is deposited on the soil of interest, this is still a factor of about 20 less than the 0.001 curie used for Reference 18 calculations. Hence, the actual maximum individual total body dose through the soil pathway would be 0.004 mrem/yr. This is about 0.01 percent of the natural terrestrial background, or alternatively, this yearly dose is slightly less than the hourly exposure from natural sources of radioactivity from the earth.

PSNS concludes there has been no adverse impact on human health or the environment due to the soil exposure pathway.

8.4 Air Pathway

The air pathway considers potential exposure threats to people and to sensitive environments via migration through the air.

As discussed in Section 5, except in 1984, air discharged from radiological work facilities contains less radioactivity than an equivalent amount of environmental air containing naturally occurring radioactivity. When quality analytical evidence shows that exhaust air from a facility is cleaner than environmental air and the facility has a long history of air control measures, such as HEPA filtered and monitored exhausts, no individual on-site or within the four mile radius of concern is receiving significant exposure above that being received from naturally occurring radionuclides.

Other potential sources of airborne radioactivity, such as from contaminated soil or spills of contaminated liquids, have been discussed in other sections of this report. Based on the rarity and trace level of detectable soil contamination, and the immediate containment and recovery actions taken for spills, PSNS considers these potential sources of airborne radioactivity have been eliminated from consideration.

8.4.1 Release Mechanisms Affecting the Air

The methods employed to prevent the release of radioactivity into the atmosphere were discussed in Section 4.4 and have proven to be extremely effective. Nevertheless, consideration of atmospheric releases is necessary since such releases would potentially allow radioactivity to contact the soil and surface water. Some mechanisms that could cause an atmospheric release of radioactivity follow.

8.4.1.1 Potential Releases from Ventilation Systems

Facilities that are used for radioactive work or work with radioactive materials are potential sources of airborne radioactivity. High efficiency particulate air (HEPA) filtered ventilation systems are used in these facilities and could fail before or during work and allow radioactive particulates to enter the atmosphere. Potential failure modes for HEPA filters include: improper installation, damage during installation or use, improper differential pressure testing, or exceeding HEPA filter capacity. In addition, duct work associated with these ventilation systems could fail or become damaged causing an uncontrolled release.

8.4.1.2 Potential Releases from Storage Areas

The primary atmospheric release potential from radioactive material storage areas would be a fire. NNPP regulations specify that buildings where radioactive materials are stored shall be constructed and equipped with fire protection systems in accordance with Reference 26. These provisions include building construction, fire detection and alarm systems, automatic sprinkler systems, portable fire extinguishers, and fire hydrants. In addition to structure requirements, NNPP regulations: require that materials be stored in fire retardant containers; prohibit welding, burning, or other operations that could cause a fire without prior authorization; and require periodic inspections and fire drills.

Another potential release mechanism is the possibility of the loss of containment for items being stored, including tears in packaging material.

8.4.1.3 Potential Releases from Collection Tanks

Tanks containing radioactive liquid effluent present a potential for atmospheric release. If a tank were to rupture or leak, evaporation of the liquid could allow radioactive particles to become airborne. Rupture or leakage could result from corrosion of the tank, excessive pressure build-up, or human error in valve positioning. A release could also occur if a tank were to overflow during a liquid transfer.

8.4.2 Air Targets

Target populations under the air pathway consist of people who reside, work, or go to school within the 4-mile target distance limit around the site. Preliminary Assessment air pathway targets also include sensitive environments and resources.

Targets are evaluated on the basis of their distance from the site. Those persons closest to the site are most likely to be affected and are evaluated as primary targets. The nearest individual would be an on-site worker.

Like the other migration pathways, a release must be suspected in order to score primary targets for the air pathway. Releases to the air pathway, however, are fundamentally different from releases to the other migration pathways. Depending on the wind, air releases may disperse in any direction. Therefore, when a release is suspected, all populations and sensitive environments out to and including the 1/4 mile distance category are evaluated and scored as primary targets. Because air releases are quickly diluted in the atmosphere, targets beyond the 1/4 mile distance are evaluated as secondary targets.

As with other migration pathways when a release is not suspected, the residential, student, and worker population within the entire 4-mile target distance limit is evaluated as the secondary target population. The population distribution for the secondary target population is given in Sections 3 and 8.3.2.

Sensitive environments are defined as terrestrial or aquatic resources, fragile natural settings, or other areas with unique or highly-valued environmental or cultural features.

Typically, areas that fall within the definition of "sensitive environment" are established and/or protected by State or Federal law. Examples include National Parks, National Monuments, habitats of threatened or endangered species, wildlife refuges, and wetlands. Sensitive environments are discussed in Section 8.2.2.

Sinclair Inlet is a sensitive environment within 1/2 mile of the shipyard. However, commercial and recreational shellfish harvesting is prohibited in Sinclair Inlet.

The resources factor accounts for land uses around the site that may be impacted by release to the air:

- Commercial agriculture
- Commercial silviculture (e.g., tree farming, timber production, logging)
- Major or designated recreation area (e.g., municipal swimming pool, campground, park)

There are no commercial agriculture or silviculture land resources within 1/2 mile of the shipyard. A designated recreation area, Bremerton Boardwalk and Centennial Plaza, is within 1/2 mile of the shipyard.

8.4.3 Air Pathway Assessment

Of the pathways considered in Reference 18, the plume immersion and inhalation pathways best fit the model of Reference 25.

Table V and VII of Reference 18 present the results of calculated radiation dose estimates for immersion and inhalation. For comparative purposes, the total body dose to the maximally exposed individual is used in all cases.

Reference 18 calculates an annual total body dose of 0.0044 mrem for immersion and 0.00026 mrem for inhalation, for radionuclides of NNPP interest. This gives a combined dose of 0.0047 mrem for this pathway. For inhalation, only cobalt-60 and carbon-14 contribute significantly to exposure. For immersion, cobalt-60, carbon-14, tritium, and all fission product noble gases as listed in Table V of Reference 18 are considered.

This represents a maximum value since the assumed releases of Table V are significantly higher than actual. For example, for cobalt-60, the primary radionuclide of interest for NNPP nuclear facilities, the calculations are based on 0.001 curie per year. Table 5-3 shows that the maximum possible release occurred in 1981 and totaled 4.4×10^{-5} curie or a factor of about 20 less.

Comparing the Reference 18 combined dose of 0.0047 mrem/yr to the dose from natural sources of radiation listed in a report published by the National Council on Radiation Protection and Measurements (Reference 6), the calculated combined dose is about 0.0024 percent of that due to airborne natural background radioactivity (primarily radon). When the actual PSNS release values are factored in, the comparative percentage becomes vanishingly small.

Since 1989, PSNS has used the Environmental Protection Agency COMPLY computer program to provide a quantitative estimate of the radiation exposure to which any member of the general public might be exposed as a result of radioactivity in airborne effluents. This analysis is performed in accordance with EPA regulations in 40 CFR 61 Subpart I. Site-specific input parameters include radionuclide releases and distance to members of the public. Cobalt-60 values include actual measurements of cobalt-60 emissions from the exhaust of monitored ventilation in addition to very conservative estimates of other potential sources of cobalt-60. Values for other airborne radionuclides, including iodine-131, are conservative estimates based upon detailed study of land-based Naval nuclear propulsion prototype plants; for example, the very conservative assumption that half of the radioactive water handled by PSNS evaporates from collection and storage tanks. Thus, the actual exposures to members of the public are expected to be lower than the results of this analysis.

Since the controls for airborne releases have remained the same over the years, the assessment for 1993 can be used for evaluation purposes. The result of the airborne effluent analysis in 1993 was 0.066 millirem from particulate and gaseous radionuclides and 0.00011 millirem from radioiodine releases. The estimated maximum radiation exposure to a member of the general public from releases of airborne radioactivity is much less than the standard of 10 millirem per year established by the Environmental Protection Agency in 40 CFR 61.

Although the COMPLY methodology gives somewhat higher estimates than the methodology used in Reference 18, the estimates obtained continue to be insignificant.

These comparisons provide additional evidence that the airborne exposure to any potential target due to NNPP activities at PSNS is insignificant.

9.0 Conclusions

Evaluation of the information and analytical data presented in this HRA leads to the conclusion that past and current activities at the shipyard associated with work on Naval nuclear propulsion plants have had no adverse impact on the human population or ecosystem of the region.

Of all the radiological parameters monitored and reported as part of the longstanding and continuing monitoring of the radiological environment, only the trace cobalt-60 found in a few isolated harbor sediment samples could be considered for remediation.

To the extent that the goal of the CERCLA process is to identify and remediate those sites where harm to the environment or to human populations is occurring or is likely to occur, active removal of the harbor sediments containing the low levels of cobalt-60 would do more harm to the benthic organisms and dependent biota than the possible radiation exposure received over the time required for the radioactivity to decay to undetectable levels.

The findings and conclusions of the Environmental Protection Agency surveys reported in 1977 and 1989 appear to PSNS to be consistent with the data and conclusions of this assessment as quoted in Section 6.1.1 and repeated in part below:

The 1974 Environmental Protection Agency survey concluded:

"The continuation of the current practices regarding waste discharge and the Navy monitoring program should assure continued absence of significant public exposure for routine nuclear ship operations."

The 1987 Environmental Protection Agency survey concluded:

"Based on these surveys, current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in significant population exposure or contamination of the environment."

PSNS will continue to follow NNPP radiological control practices and perform environmental monitoring as discussed in this HRA. Within the framework of the CERCLA process, no further action is warranted regarding radioactivity associated with the Naval Nuclear Propulsion Program at Puget Sound Naval Shipyard.

GLOSSARY

- Aquifer:** A saturated subsurface zone from which drinking water is drawn.
- CERCLA:** Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Legislation that established the Federal Superfund for response to uncontrolled releases of hazardous substances to the environment.
- CERCLIS:** CERCLA Information System. EPA's computerized inventory and tracking system for potential hazardous waste sites.
- Conservative:** Tending to overestimate any potential negative impact.
- CPW:** Controlled pure water.
- Coastal Tidal Waters:** Surface water body type that includes embayments, harbors, sounds, estuaries, back bays, etc. Such water bodies are in the interval seaward from the mouths of rivers and landward from the 12-mile baseline marking the transition to the ocean water body type.
- curie:** Abbreviated Ci. A unit of measure of the amount of radioactivity equal to 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute.
- EPA:** U.S. Environmental Protection Agency. The federal agency responsible for action under CERCLA.
- Factor:** The basic element of site assessment requiring data collection and evaluation for scoring purposes.
- FFA:** Federal Facilities Agreement. An agreement among the EPA, state, and site detailing the extent and schedule for remedial actions.
- Fishery:** An area of a surface water body from which food chain organisms are taken or could be taken for human consumption on a subsistence, sporting, or commercial basis. Food chain organisms include fish, shellfish, crustaceans, amphibians, and amphibious reptiles.
- G-RAM:** General Radioactive Material. Radioactive materials that are not associated with the NNPP.

GLOSSARY (con't)

HEPA filter: High Efficiency Particulate Air Filter. A filter that will remove 99.97% of 0.3 micron particulates from an air system.

HRA: Historical Radiological Assessment. A compilation of site historical radiological data derived from the site environmental monitoring program and other records. This document is intended to be an integral part of a FFA.

HRS: Hazard Ranking System. EPA's principal mechanism for placing sites on the NPL.

IAS: Initial Assessment Study. A study done under the Navy's Installation Restoration program. This study parallels the PA.

kcpm: Thousand counts per minute.

micro: Abbreviated μ . A prefix denoting a one-millionth part (10^{-6}).

micron: A millionth of a meter (10^{-6}m).

milli: Abbreviated m. A prefix denoting a one-thousandth part (10^{-3}).

NESHAP National Emission Standards for Hazardous Air Pollutants

NNPP: Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities.

NPL: National Priorities List. Under the Superfund program, the list of sites of releases and potential releases of hazardous substances, pollutants, and contaminants that appear to pose the greatest threat to public health, welfare, and the environment.

No Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is not likely to have been released to the environment.

PA: Preliminary Assessment. Initial stage of site assessment under CERCLA; designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

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GLOSSARY (con't)

pico: Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).

PSNS: Puget Sound Naval Shipyard.

R: Roentgen. A unit of exposure. For cobalt-60 radiation, a roentgen and a rem are considered to be equivalent.

rem: Roentgen Equivalent Man. A measure of radiation dose.

SARA: Superfund Amendments and Reauthorization Act of 1986. Legislation which extended the Federal Superfund Program and mandated revision to the HRS.

Surface Water: A naturally-occurring, perennial water body; also, some artificially-made and/or intermittently-flowing water bodies.

Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is likely to have been released to the environment.

Target: A physical or environmental receptor that is within the target distance limit for a particular pathway. Targets may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

Target Distance Limit: The maximum distance over which targets are evaluated. The target distance limit varies by pathway; ground water and air pathways -- a 4-mile radius around the site; surface water pathway -- 15 miles downstream from the probable point of entry to surface water; soil exposure pathway -- 200 feet (for the resident population threat) and 1 mile (for the nearby population threat) from areas of known or suspected contamination.

Target population: The human population associated with the site and/or its targets. Target populations consist of those people who use target wells or surface water intakes supplying drinking water, consume food chain species taken from target fisheries, or are regularly present on the site or within target distance limits.

GLOSSARY (con't)

Terrestrial Sensitive Environment: A terrestrial resource, fragile natural setting, or other area with unique or highly-valued environmental or cultural features.

TLD: Thermoluminescent dosimeter. A device for measuring gamma radiation exposure.

Wetland: A type of sensitive environment characterized as an area that is sufficiently inundated or saturated by surface or ground water to support vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Worker: Under the soil exposure pathway, a person who is employed on a full or part-time basis on the property on which the site is located. Under all other pathways, a person whose place of full- or part-time employment is within the target distance limit.

< : Less than.

> : Greater than.

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